NEW

FOKKER D.VII • SPITFIRE SM520 • MESSERSCHMITT BF109 • P-51 MUSTANG • HARRIER GR9

HISTORY of WAR PRESENTS

GREATEST FIGHTER PLANES

★ The elite combat aircraft that have dominated the skies and revolutionised warfare ★

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F-15 EAGLE • PANAVIA TORNADO • ALBATROS D.VA • GRUMMAN F-14D TOMCAT • **& MANY MORE**

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HISTORY of WAR PRESENTS

GREATEST FIGHTER PLANES

When the hum of engines could be heard over the skies of London on 7 September 1940, it was the start of an onslaught that would push Britain to the brink. The Blitz had begun, and as aircraft went up against aircraft, there was a fight for the nation. It was a time of iconic combat planes – the famous Spitfire was born, facing off against the Third Reich's well-known Messerschmitt BF 109G. But it wasn't a new spectacle.

The first fighter aircraft the world had ever seen were built in French fields about 25 years before. Since then, countries have raced to improve flight technology to gain control of the skies.

In History of War's Greatest Fighter Planes, climb into the cockpit of the revolutionary Voisin III and see the world from a Mitsubishi A6M 'Zero'. Find out how the Hawker Hurricane and Spitfire SM520 became so iconic of an era, and what advancements were made for the Cold War's Gloster Meteor FR.9 and present-day F-15 Eagle.

FUTURE

HISTORY of WAR PRESENTS

GREATEST FIGHTER PLANES

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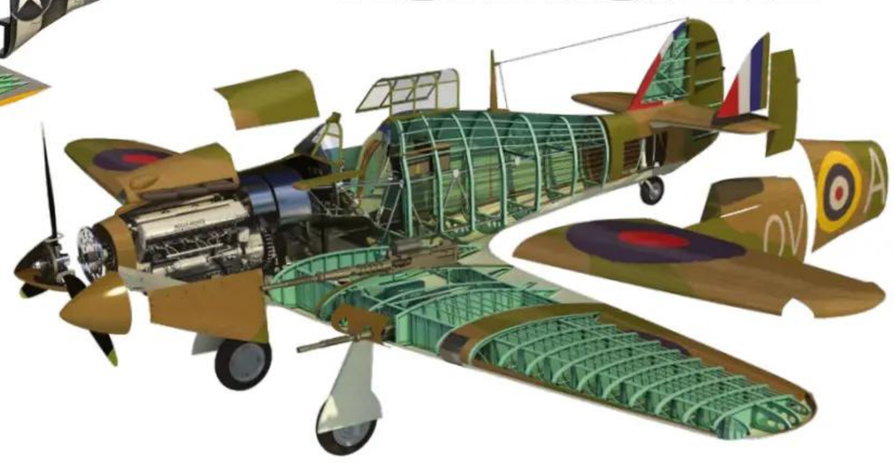

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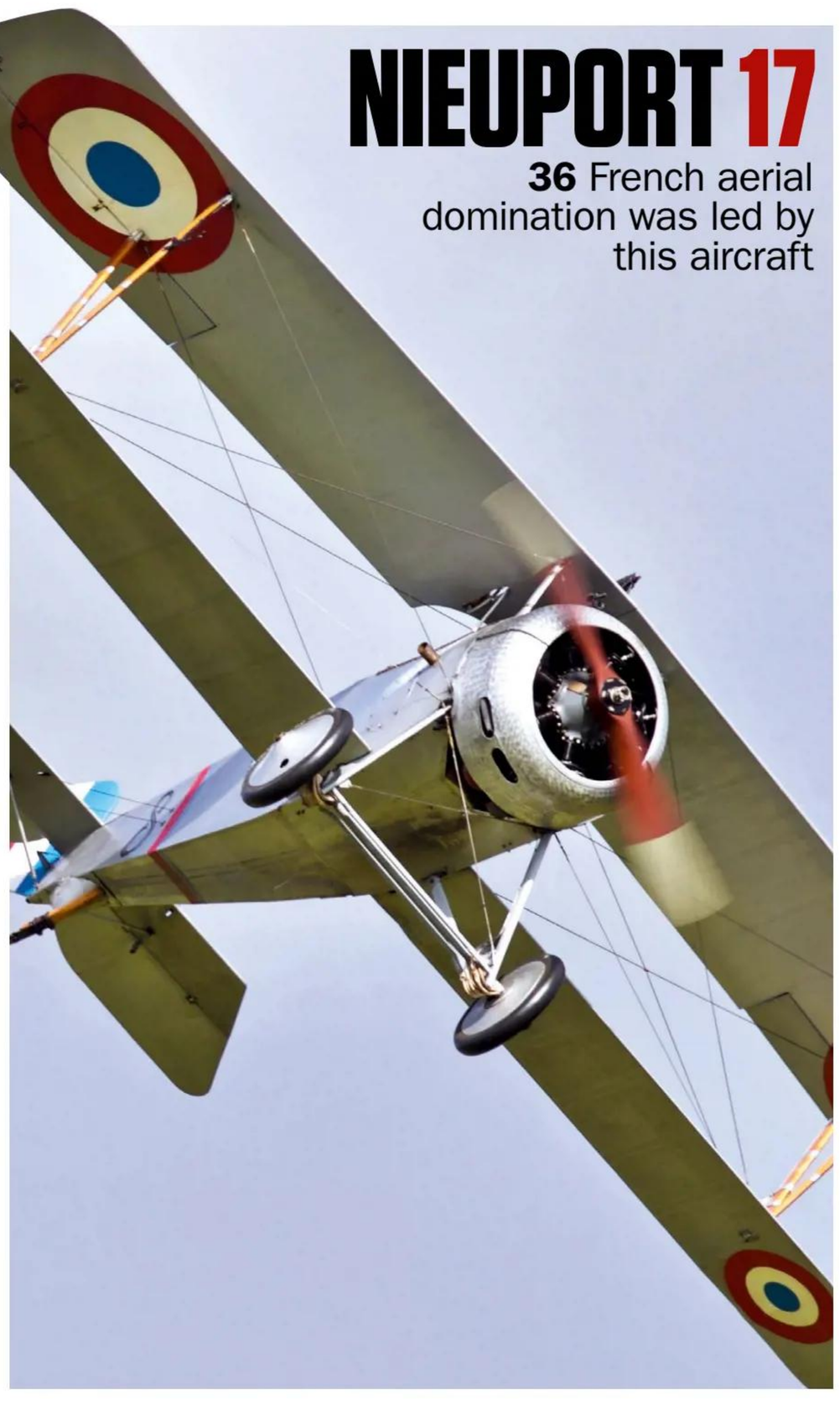

ALBATROS D.VA

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VOISIN III

This pusher biplane was a standard bomber for the Allies in the early years of World War I

MACHINE GUN
The Hotchkiss M1914 machine gun was mounted onto the fuselage and operated by a standing observer.

LIGHTWEIGHT FRAME
Thanks to its lightweight steel fuselage, the Voisin III could reach a top speed of 113km/h (70m/h) and had a range of 200km (124m).

While it may not look like much by today's standards, the Voisin III holds a unique place in history: on 5 October 1914, it became the first aircraft in World War I to win an aerial fight and shoot down an enemy aircraft. Small as it may have been, it had proved its worth.

The Voisin III was created by the Voisin brothers, Gabriel and Charles. As the name suggests, others had come before it – Gabriel had been making commercial aircraft since 1905 before he joined forces with Charles two years later.

Voisin I was their first foray into military aircraft in 1912 and it took them two years to evolve it into the Voisin III in 1914. It proved effective, and more than 1,350 were built during the First World War. They didn't just serve in France's Aéronautique Militaire and the French Navy, either – they were supplied to, or built under license by, 12 other countries, including Britain, the Russian Empire, Italy and the United States.

A pusher biplane made from a light steel frame, the Voisin brothers designed their aircraft with versatility in mind, and it was used for reconnaissance and training. Perhaps its most important use was as one of the world's first dedicated bombers. Able to hold a bomb load of about 150 kilograms (330 pounds), it became part of France's bombing strategy as the country became the first to organise dedicated bomber units on the Western Front. On 14 August 1914, a fleet of Voisins were sent in to attack German airship hangers in what is believed to have been the first ever organised bombing attack in history. As the war drew on, men would fly day and night to drop their payloads on their targets, with a near-unopposed bombing onslaught taking place in early 1915.

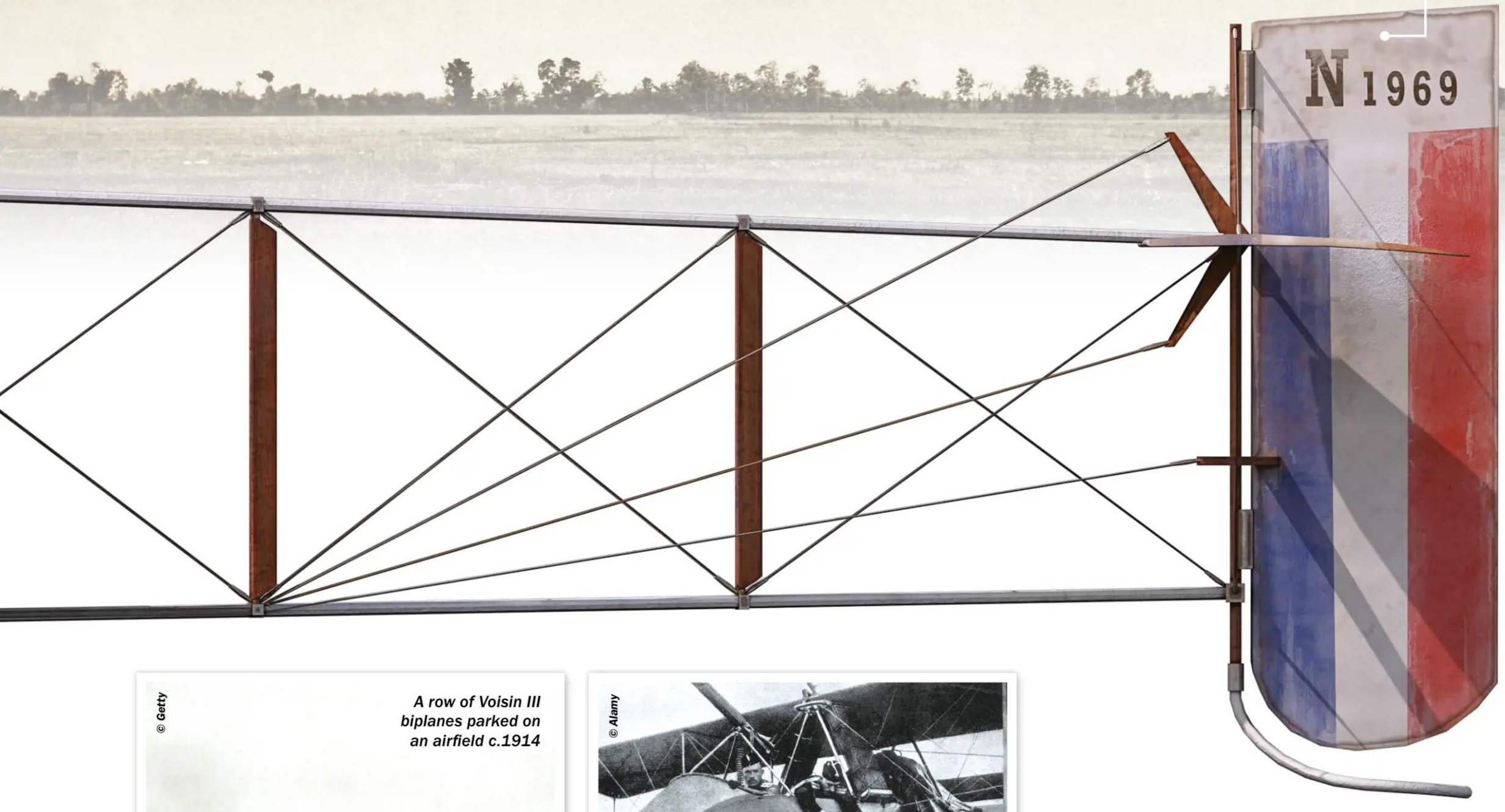
Photograph of a Voisin III biplane taking off in Italy during World War I

"JUST A FEW MONTHS INTO WORLD WAR I, A VOISIN III BECAME THE FIRST PLANE TO SHOOT DOWN AN ENEMY IN THE SKY"

FRENCH MADE

While the Voisin III was French in its design, Russia bought 800 and made another 400 under license, while 100 were built in Italy and another 50 in the UK.

© Getty



A row of Voisin III biplanes parked on an airfield c.1914

© Alamy

Left: A Russian officer fixing a bomb onto a Voisin III

Its other use was as one of the earliest attack aircrafts that Europe had ever seen – and it was effective. Just a few months into World War I, a Voisin III became the first plane to shoot down an enemy in the sky. Over Jonchery, Reims, Sergeant Joseph Frantz and Corporal Louis Quénault became French heroes as they caught a German Aviatik B.II with their machine gun fire. It would go down in history as the world's first air-to-air kill in war.

But as the war continued, so too did technological advancement. Germany was coming up with its own fighter planes now, and France no longer had the advantage in the air. While the Allies were still innovating and bringing out new aircrafts, it seemed like there was no longer a place for the Voisin III. It was becoming increasingly vulnerable to new German fighters and its newer models like the Voisin V and Voisin VIII were able to withstand attacks from the enemy.

As it became clear that the Voisin III was now obslete, it was eventually phased out of commission, and production stopped in 1916. But although it could no longer hold its own in the war-torn skies of Europe, it had certainly more than proved its worth during the early years of World War I.

VOISIN III

COMMISSIONED:	1914
ORIGIN:	FRENCH
LENGTH:	9.5M (31FT 2IN)
WINGSPAN:	14.74M (48FT 4IN)
ENDURANCE:	4.5 HOURS
ENGINE:	SALMSON M9 (150HP)
CREW:	2
WEAPONS:	1 X HOTCHKISS M1914 FUSELAGE-MOUNTED MACHINE GUN

Illustration: Nicholas Forder

BRISTOL F.2B

BARN DOOR NOSE
The distinctive broad nose of the Bristol Fighter was made up of louvered slats that could be adjusted to regulate airflow for the engine.

VANTAGE POINT
The fuselage hung 'mid-gap', above the lower wing. This gave the pilot a better forward view over the top wing.

STABILISERS
The Biff was notoriously wobbly on the ground. These hoops were designed to stop wing tips digging into the earth and damaging the aircraft.

WORDS **STUART HADAWAY**

Britain's superb all-round two-seater that arrived in the wake of Bloody April

Introduced in 1917, the Bristol F.2 Fighter got off to rocky start with Britain's Royal Flying Corps (RFC), and early models were plagued with engine trouble. However, once fitted with the Rolls Royce Falcon, the F.2b proved to be one of the most outstanding aircraft of the First World War. As a two-seater it could carry out bombing, photographic reconnaissance and ground attack operations with speed and ease, but it also had the agility of a true fighter and could dogfight with the best. In the summer of 1917, this was just the aircraft the RFC needed to regain air superiority over the Western Front, where it gained the affectionate nickname of the 'Biff'.

Its reliability, strength and all-round abilities led to its continued service in the fledgling Royal Air Force (RAF) and other forces in the 1920s and 1930s. Well suited to the rough conditions of the North West Frontier and Iraq, and able to fulfil several roles for the cost of one, it suited the over-stretched and cash-strapped RAF well. It became an icon of inter-war Imperial Policing and carried on until 1932 when the F.2b was finally withdrawn from RAF service.

FIGHTER

BRISTOL F.2B FIGHTER

COMMISSIONED:	1916
ORIGIN:	BRITISH
LENGTH:	7.87M (25FT 10IN)
WINGSPAN:	11.96M (39FT 2IN)
ENDURANCE:	3 HOURS
ENGINE:	ROLLS ROYCE FALCON 205KW (275HP) V12 AIR COOLED INLINE ENGINE
CREW:	2
WEAPONS:	1 X VICKERS .303IN (7.7MM) MACHINE GUN, 2 X LEWIS .303IN (7.7MM) MACHINE-GUNS, 110KG (240LB) OF BOMBS, 270KG (600LB) OF BOMBS

Illustration: Battlefield Design

ALDIS GUNSIGHT

Made up of lenses with sighted rings marked on them, this non-telescopic sight was ideal for long range shooting, but less use in a swirling dogfight.

ALL ROUND FIELD OF FIRE

The Scarff Ring was British invention that allowed the machine-guns to be swung quickly to face almost any direction.

"ITS RELIABILITY, STRENGTH, AND ALL-ROUND ABILITIES LED TO ITS CONTINUED SERVICE IN THE FLEDGLING ROYAL AIR FORCE"

***Below and below, right:** Bristol fighters in flight circa 1920*

Image: Wiki / PD / Gov

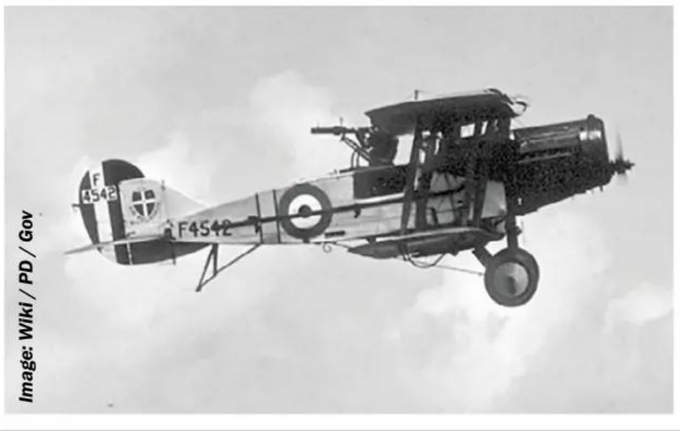


Image: Wiki / PD / Gov

Bristol Fighter picking up a message from the ground, 1920s

Images: Alamy

Two Australians pose with their potent sting-in-the-tail, Palestine, 1918

Source: Wiki / PD / Australian Flying Corps

“CREWS SOON FOUND IT WAS BEST TO FLY IT AS IF IT WERE A SINGLE SEATER, WITH THE PILOT CONCENTRATING ON THE ‘KILL’ WHILE THE OBSERVER WATCHED THEIR TAIL”

ARMAMENT

The Bristol Fighter had a single fixed forward-firing belt-fed Vickers .303in (7.7mm) machine gun operated by the pilot, while the observer in the rear had one or two .303in (7.7mm) Lewis drum-fed machine-guns on a Scarff Ring. Designed as a two seater, crews soon found it was best to fly it as if it were a single seater, with the pilot concentrating on the ‘kill’ while the observer watched their tail. A bombload of up to 12 x 20lb (9.2kg) Cooper bombs could also be carried.

***Right:** The pilot’s gun fired directly ahead, through the top of engine block*

Source: Wiki / PD / CC / Alan Wilson

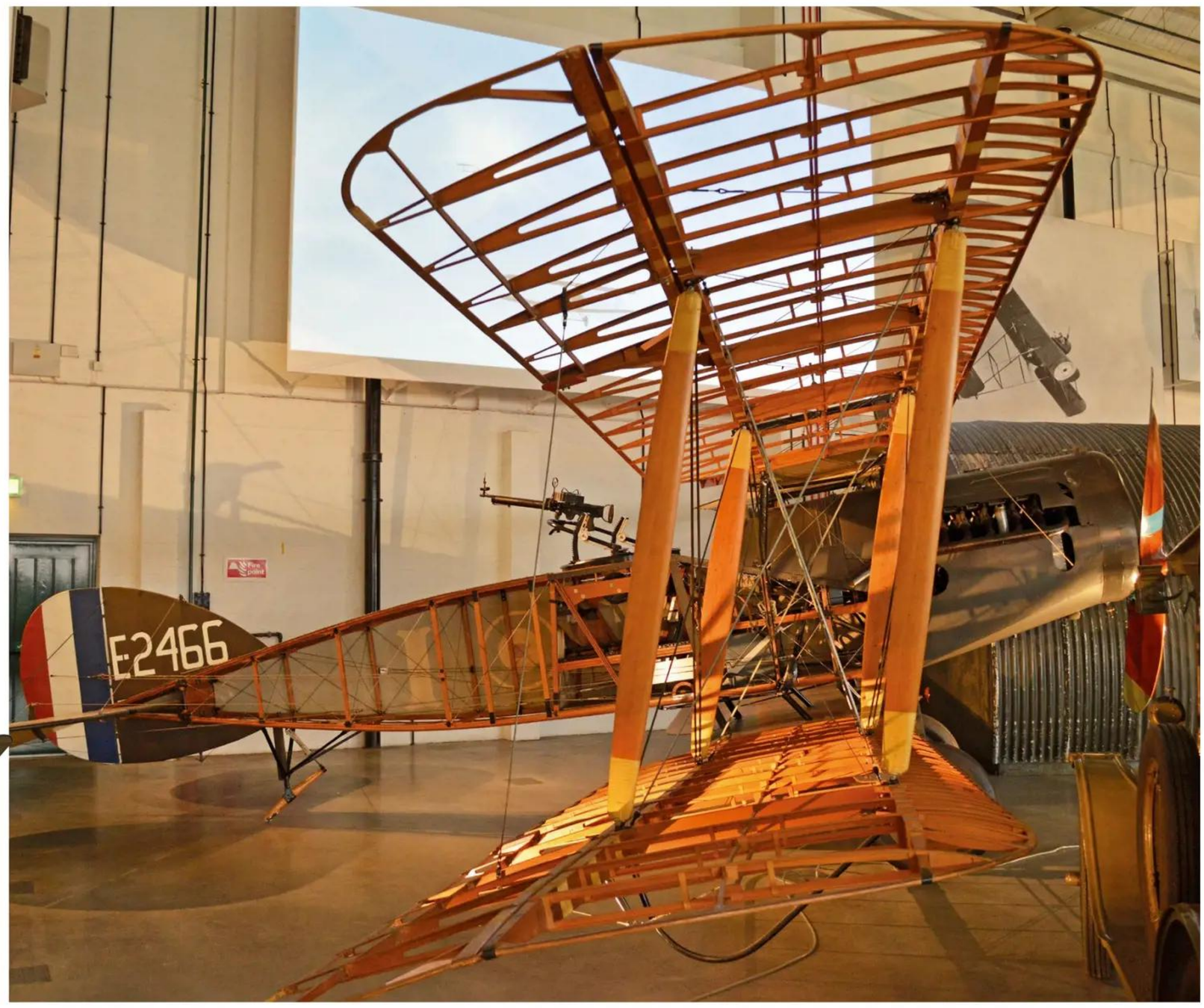
DESIGN

The Biff's strength literally lay in its immensely strong wooden framework. Its solid construction allowed it to be thrown around the sky like a much lighter aircraft, and provided good survivability. The highly sprung suspension made it 'waddle' when taxying, and it could easily tip and snag a wing or break a wheel while taking off or landing. In fact, in the interwar period they commonly carried spare wheels on the fuselage when operating at rough airstrips.

***Right:** The half-stripped F.2b at the RAF Museum, Hendon, gives an excellent view of its construction*

The F.2b was stocky but streamlined, making it fast and sturdy

Source: Wiki / PD / CC / Colgill



Source: Wiki / PD / CC / Alan Wilson

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ENGINE

The early Bristol Fighters suffered from numerous engine problems as constant shortages led to a wide range of unsuitable types being used. Once available in sufficient numbers, the Rolls Royce Falcon proved ideal. A V12 air cooled inline engine, it was slow to warm up (Biffs could not 'scramble' like some contemporary fighters) but reliable and powerful in the air. It went through several developments, with the Mk. III remaining in production until 1927.

***Left:** The Rolls Royce Falcon III, the last of the developments of the type*

***Below:** A pilot and observer, in front of a Bristol F.2b Fighter*

Source: Wiki / PD / Australian Government

SERVICE HISTORY

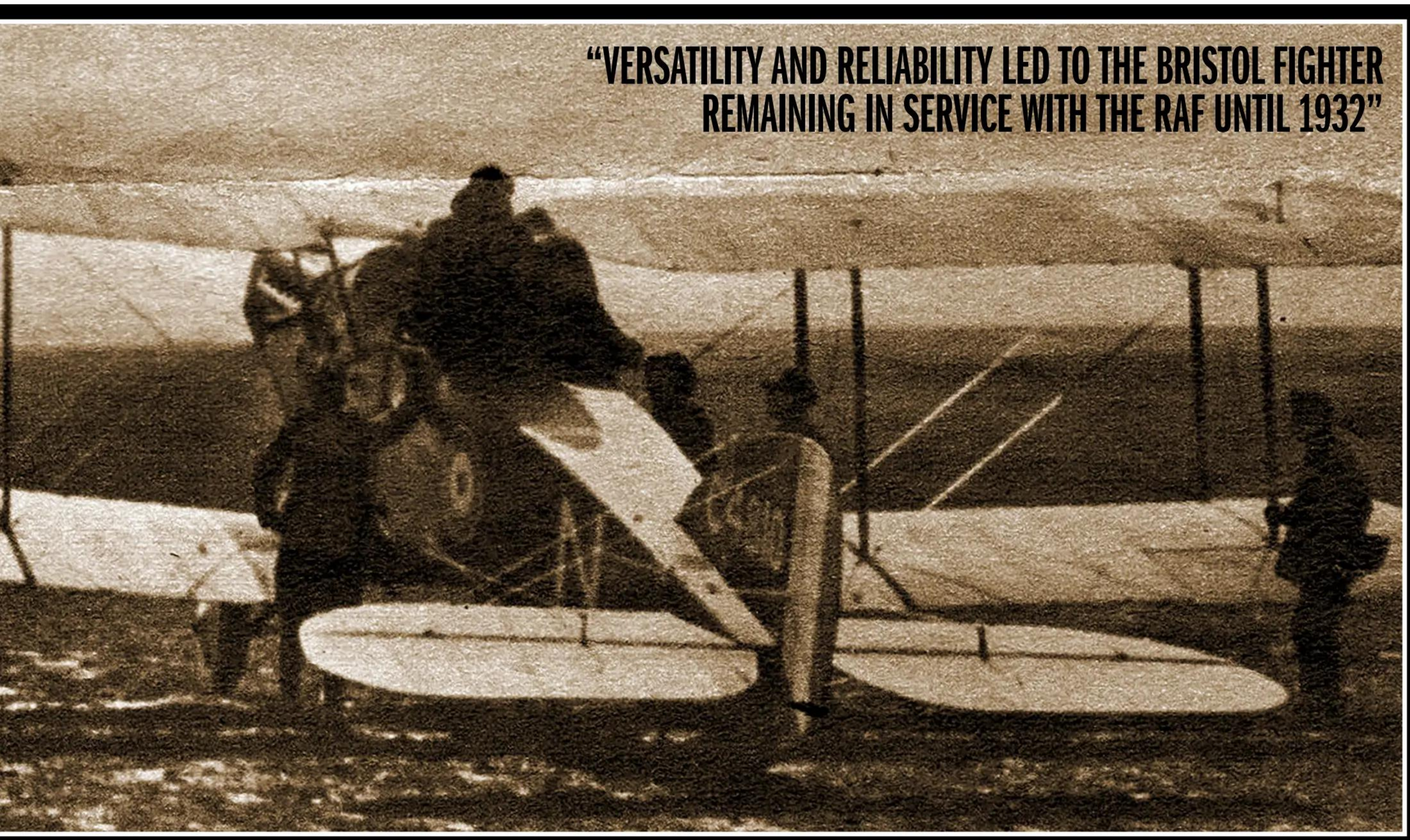
The Bristol Fighter was designed in 1916 to replace the venerable BE2. Engine problems delayed introduction, and its first use in 'Bloody April' 1917 was disastrous as crews flew the type like a typical two-seater, with a defensive mind-set. When the upgraded F.2b entered service in June 1917, the crews quickly realised the Biff's potent offensive streak, and it went from strength to strength. Better than most contemporary German fighters, even towards the end of 1918 it was competitive against the very latest enemy machines. Biffs were used for Home Defence in the UK, in Italy, and the arrival of just six F.2bs over Palestine in October 1917 won Britain air superiority in that theatre.

Its versatility and reliability led to the Bristol Fighter remaining in service with the RAF until 1932, principally serving in the rugged and unforgiving environments of the North West Frontier of India and in Iraq.

Bristol Fighters queue for take off, France, 1918

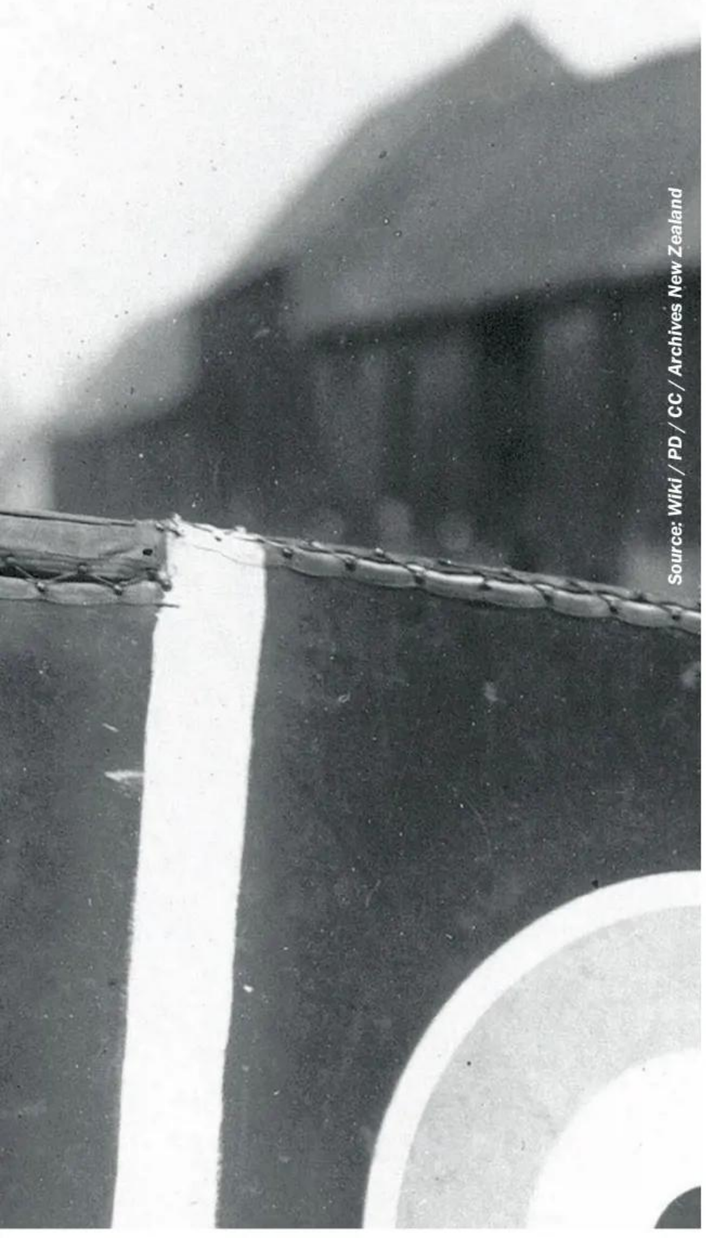
Bristol Fighter on field at Agincourt, July 1918

Source: Wiki / PD / Andrew Helme



"VERSATILITY AND RELIABILITY LED TO THE BRISTOL FIGHTER REMAINING IN SERVICE WITH THE RAF UNTIL 1932"

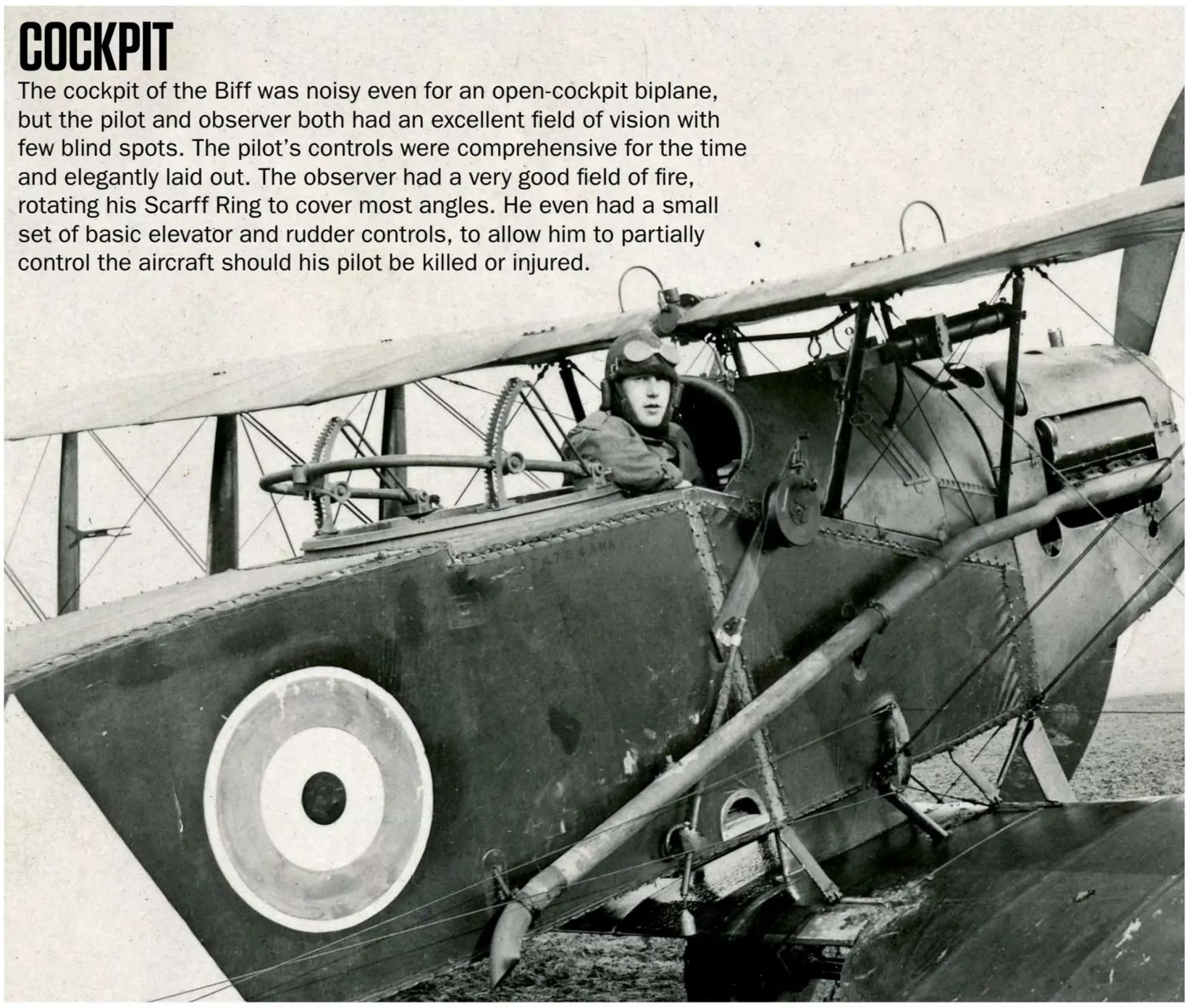
The observer had a very clear all-round field of view



Source: Wiki / PD / CC / Archives New Zealand

COCKPIT

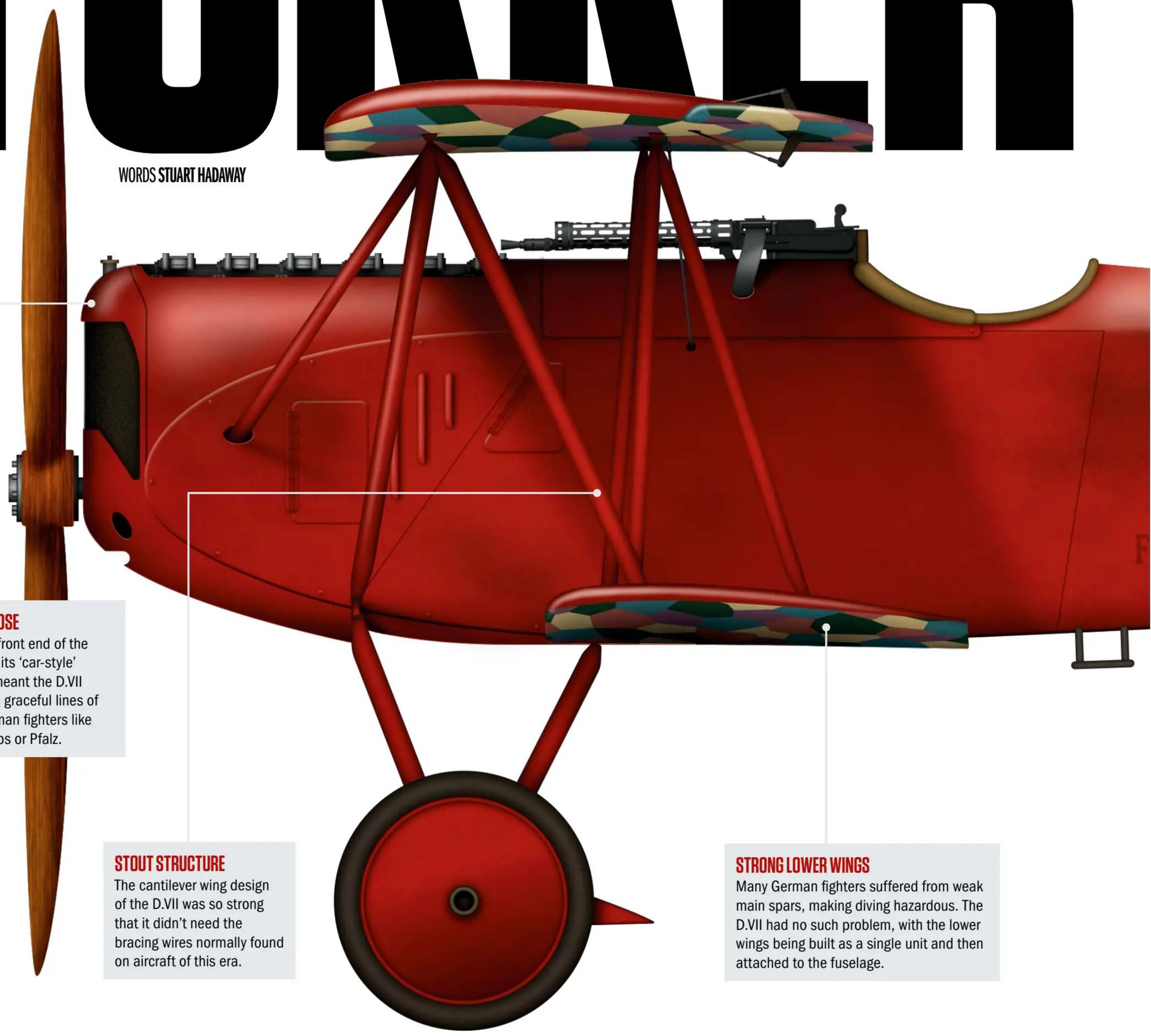
The cockpit of the Biff was noisy even for an open-cockpit biplane, but the pilot and observer both had an excellent field of vision with few blind spots. The pilot's controls were comprehensive for the time and elegantly laid out. The observer had a very good field of fire, rotating his Scarff Ring to cover most angles. He even had a small set of basic elevator and rudder controls, to allow him to partially control the aircraft should his pilot be killed or injured.



Source: Wiki / PD / CC / Provincial Archives of Alberta

FOKKER

WORDS **STUART HADAWAY**



SQUARE NOSE
The blunt front end of the D.VII, with its 'car-style' radiator, meant the D.VII lacked the graceful lines of other German fighters like the Albatros or Pfalz.

STOUT STRUCTURE
The cantilever wing design of the D.VII was so strong that it didn't need the bracing wires normally found on aircraft of this era.

STRONG LOWER WINGS
Many German fighters suffered from weak main spars, making diving hazardous. The D.VII had no such problem, with the lower wings being built as a single unit and then attached to the fuselage.

Arguably the best fighter of the First World War, the Fokker D.VII arrived too late to save the German air forces

The Fokker D.VII was one of the best, some would say *the* best, fighter aircraft of World War I. It was fast, manoeuvrable and a forgiving aircraft to fly, and it didn't suffer from the structural problems that plagued many other German fighters. It could be placed in the hands of a novice and perform well, while in the hands of an expert it was truly formidable.

Designed by Reinhold Platz, Chief Designer at the Fokker works, the already excellent aircraft was further refined by Anthony Fokker. The metal tubular frame gave it strength, and its docile stall characteristics allowed a pilot to 'hang on his prop' at the top of a climb for precious seconds, remaining in control when most other aircraft would have already fallen into a spin.

D.VII

FOKKER D.VII	
COMMISSIONED:	1918
ORIGIN:	GERMANY
LENGTH:	7M (23FT)
WINGSPAN:	8.9M (29FT)
ENGINE:	138KW (185HP) BMW IN-LINE AIR-COOLED
CREW:	1
PRIMARY WEAPON:	2 X SPANDAU LMG08/15 7.92MM MACHINE GUNS

Illustration: Battlefield Design

RED BARON'S RECOMMENDATION

The triangular portion of the tail was added after test flights by Manfred von Richthofen, aka the Red Baron. The fuselage was also lengthened to improve directional control, especially in a dive.

"SO FEARED WAS THE FOKKER D.VII THAT WHEN THE FIRST WORLD WAR ENDED THE VICTORIOUS ALLIES INCLUDED A TERM IN THE PEACE TREATY THAT 1,700 OF THEM HAD TO BE HANDED OVER"

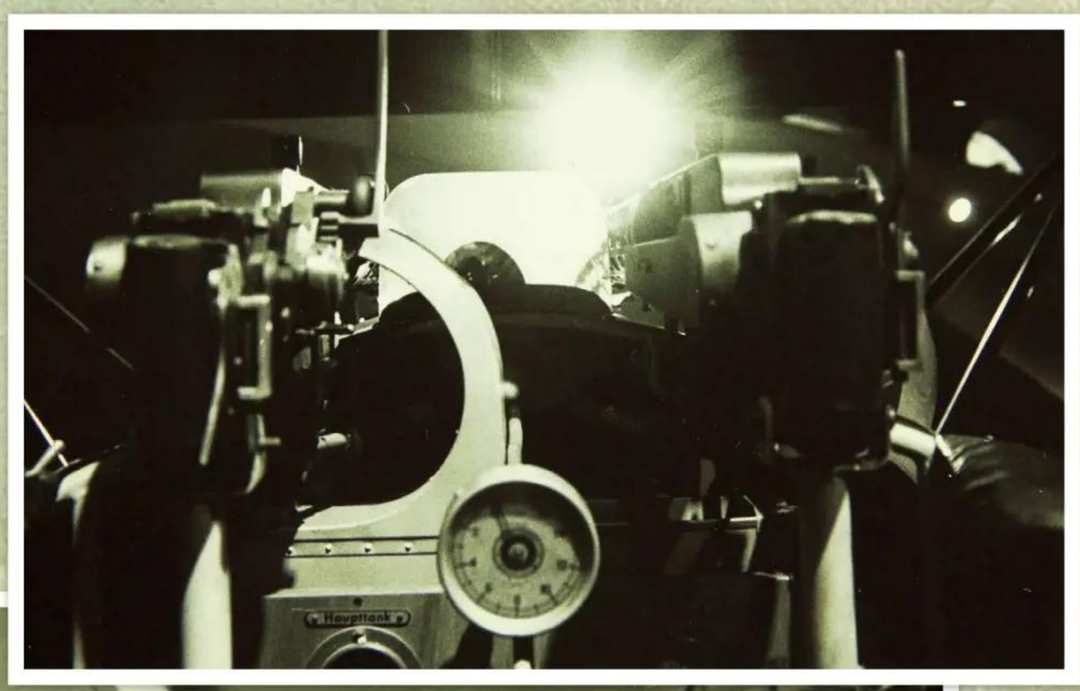
So feared was the Fokker D.VII that when the First World War ended, the victorious Allies included a term in the peace treaty that 1,700 of them had to be handed over. Intended to strip the Germans of a valuable asset, this stipulation paradoxically led to the aircraft remaining in production in Germany until well into 1919, while Fokker later managed to continue production in his native Netherlands.

A D.VII in flight

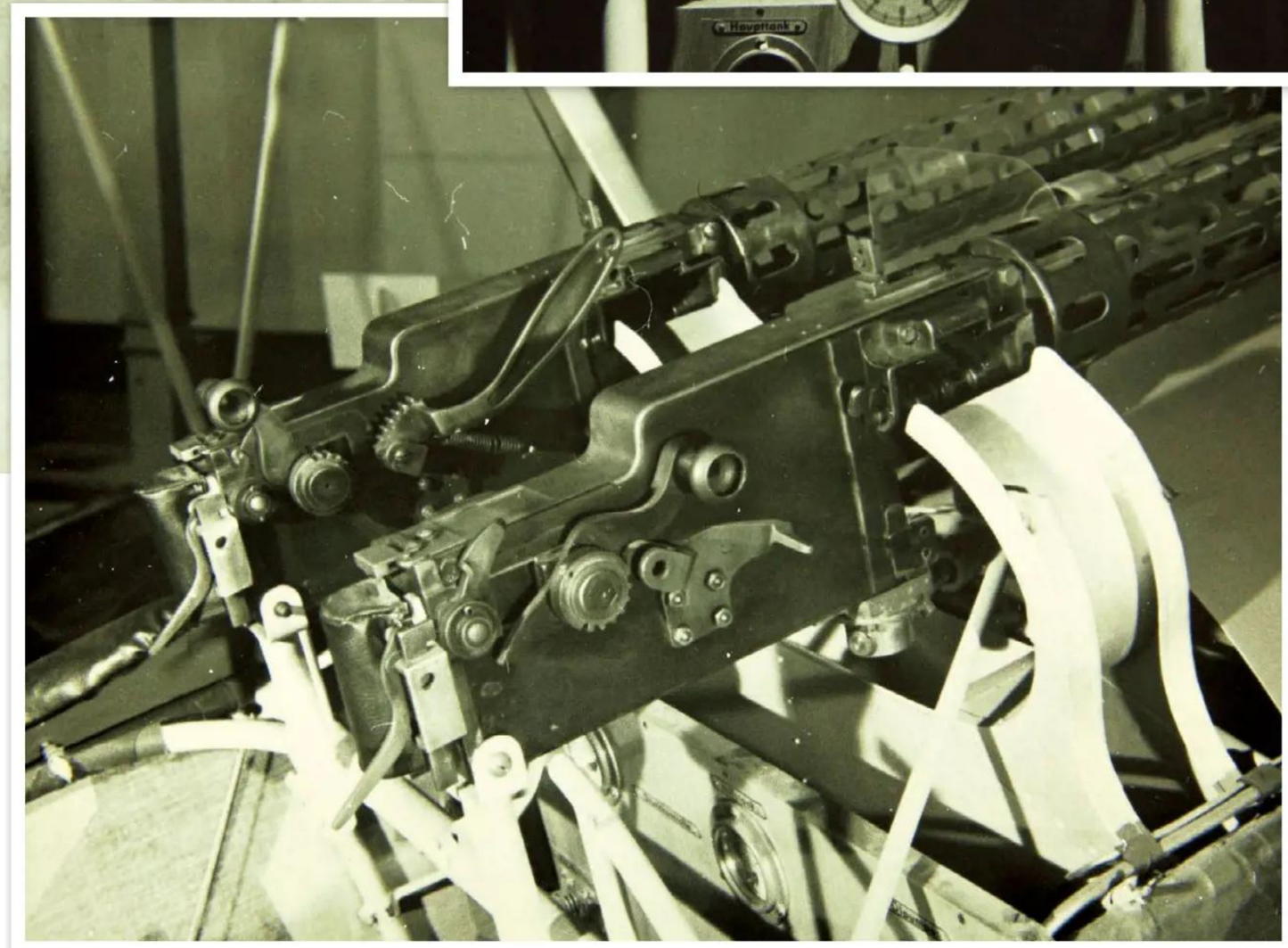
© Alamy

Some D.VIIs requisitioned after WWI were later used in movies, like these two in the Howard Hughes classic Hell's Angels

"EMPTY CARTRIDGES EJECTED THROUGH TRAYS OUT OF THE SIDE OF THE AIRCRAFT, ALTHOUGH AT CERTAIN ATTITUDES THE PILOT COULD FIND HIMSELF BEING SHOWERED IN THE HOT BRASS CASINGS"

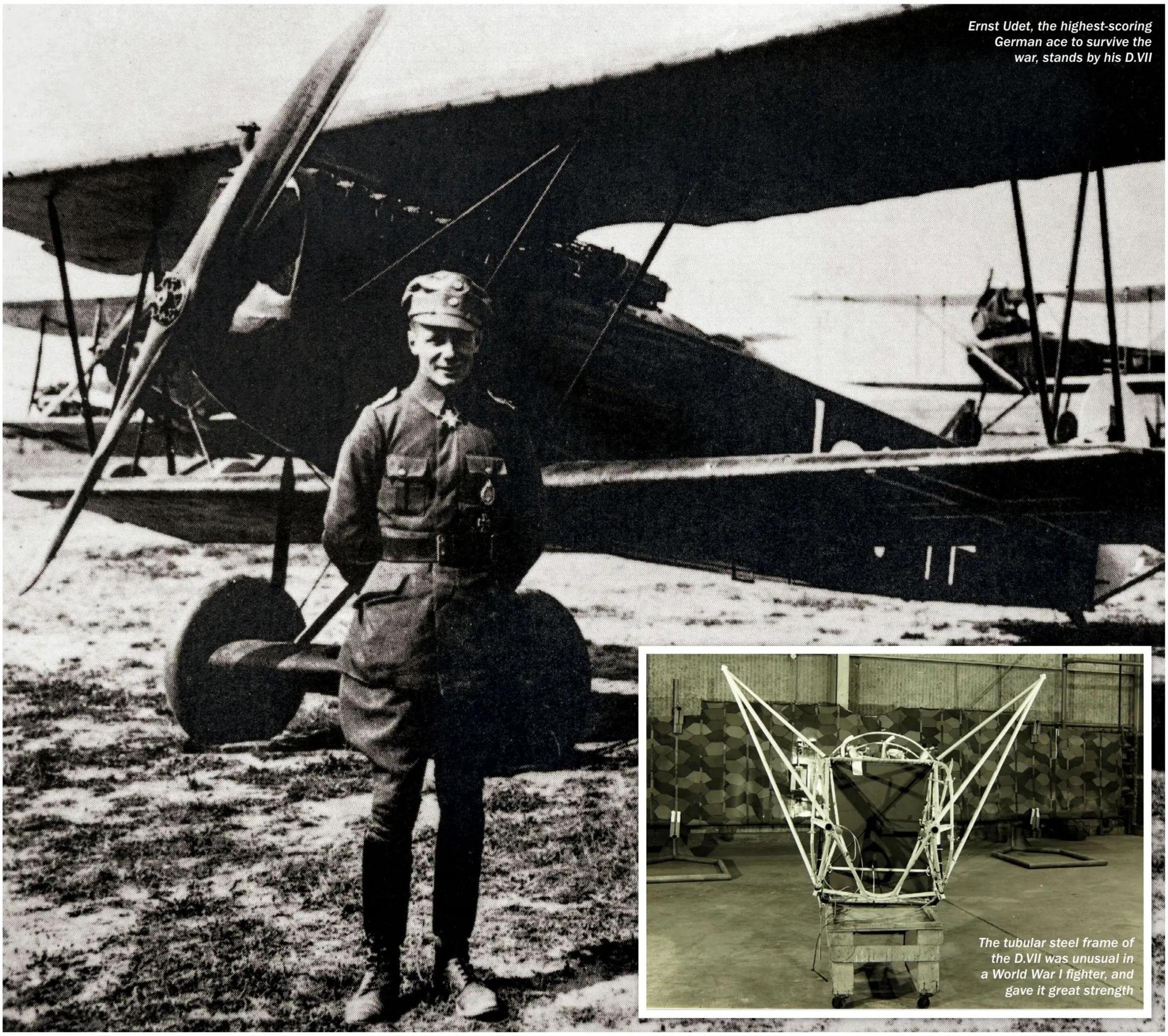


Right and below: *The twin Spandau LMG08/15s, with their belt-feed trays clearly visible. The ammunition containers, just behind the engine, were prone to overheating*



ARMAMENT

The D.VII had two LMG08/55 7.92mm belt-fed air-cooled machine guns. Containers held 500 rounds per gun, but their position just behind the engine led to several incidents early in its service where heated ammunition exploded. Empty belts were fed into another container on the other side of the gun and empty cartridges ejected through trays out of the side of the aircraft, although at certain attitudes the pilot could find himself being showered in the hot brass casings.



Ernst Udet, the highest-scoring German ace to survive the war, stands by his D.VII

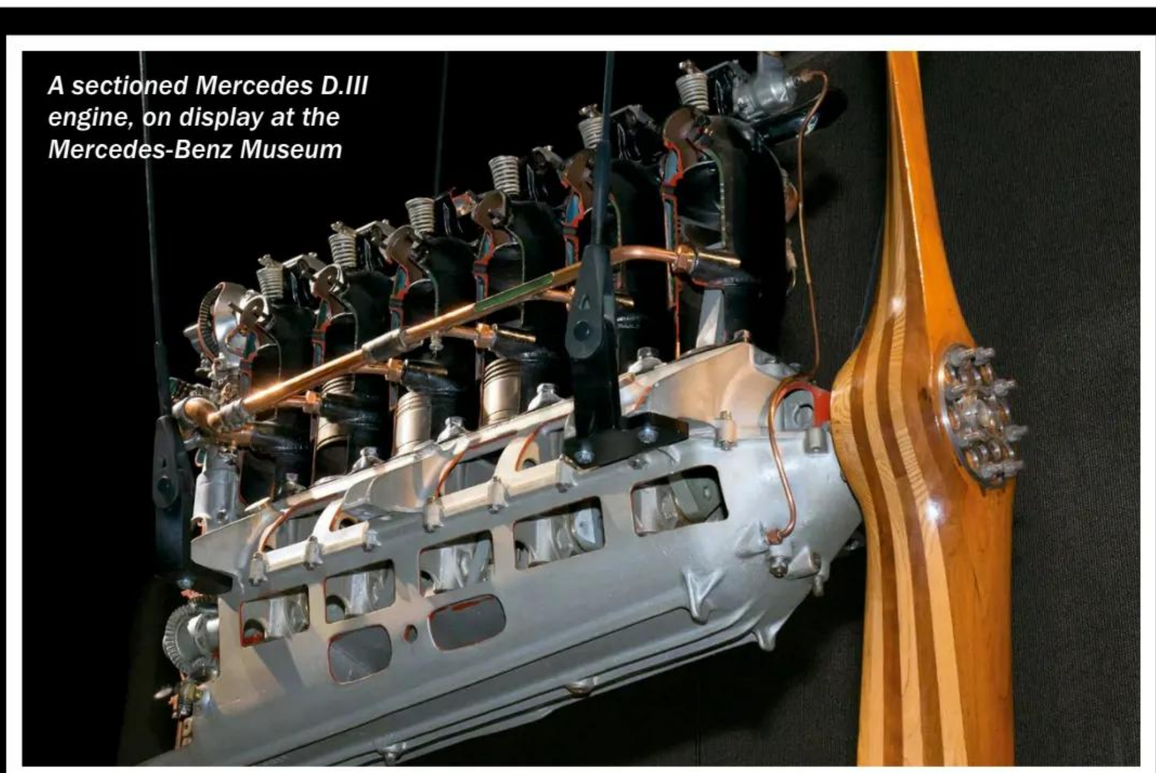
The tubular steel frame of the D.VII was unusual in a World War I fighter, and gave it great strength

DESIGN

The fuselage, tail and tailplanes of the Fokker D.VII used welded steel frames covered in fabric, making the aircraft both light and strong. Forward of the cockpit and the leading edges of the wings were covered in metal sheets, while the wings themselves were wooden framed. The lower wing was a cantilever design, with the wing built in one piece without the usual main spar. This design meant the Fokker didn't need bracing wires.

ENGINE

The D.VII was originally fitted with the 134kW (180hp) Mercedes D.IIIa and D.IIIau, but some of these were later replaced by a 138kW (185hp) BMW D.IIIa engine. Both were six cylinder in-line water-cooled engines, but the BMW was 'over-pressured' with higher compression and an altitude-adjusting carburettor. This gave it an extra boost, but at low altitudes (below 2000m/6,600ft) it could be dangerous, with a risk of significant engine damage. The BMW-equipped types were designated Fokker D.VII(F).

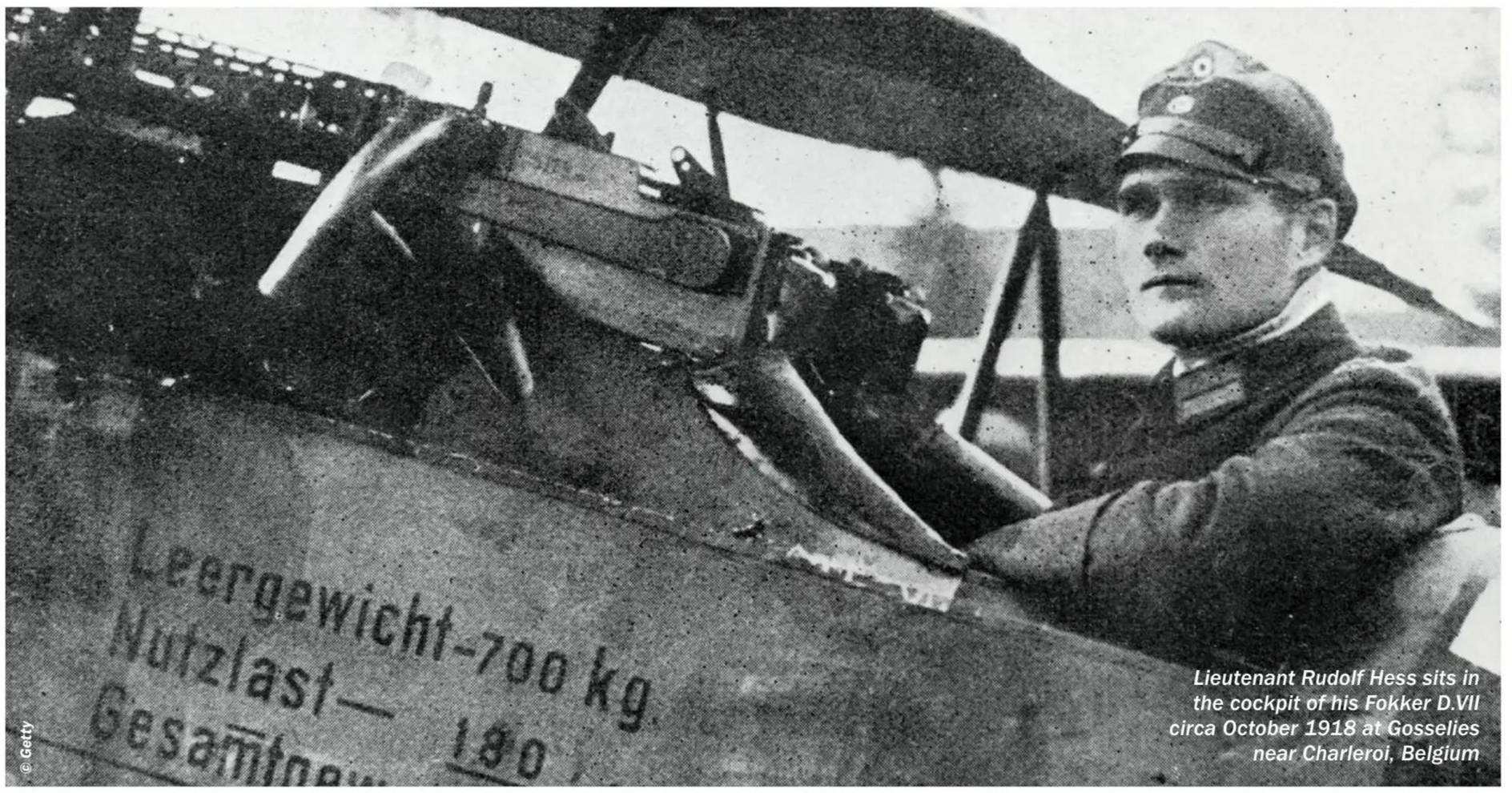


A sectioned Mercedes D.III engine, on display at the Mercedes-Benz Museum

The cockpit of the Fokker D.VII, with the tachometer prominent between the gun butts

COCKPIT

The open cockpit of the Fokker D.VII was typical of fighters in the World War I era, but with the exception that it was large enough for the pilot to wear a parachute, which was just being introduced for German aircraft crews. Ahead of the pilot were the gun butts above the instrument panel, and the compass sat by his right thigh. Like all German aircraft, the throttle was pulled back to accelerate and pushed forward to slow.



© Getty

Lieutenant Rudolf Hess sits in the cockpit of his Fokker D.VII circa October 1918 at Gosselies near Charleroi, Belgium

The D.VIIs of Jasta 72 lined up at Bergnicourt, France, July 1918

Lieutenant Gunther von Buren (centre) of Jasta 18 poses with his D.VII

SERVICE HISTORY

The Fokker D.VII was selected in the German fighter trials of January 1918 by a board that included Germany's highest ace, 'Red Baron' Manfred von Richthofen. The first planes arrived on the Western Front in late April 1918, and while Richthofen was by that time dead, the first D.VIIs went to his old unit. Allied pilots soon came to respect the new type – it may have lacked the graceful lines of many other German fighters but it also lacked their structural weaknesses. It was fast, manoeuvrable, easy to fly and deadly even in relatively inexperienced hands. However, the D.VIIs were too little, too late to prevent German defeat.

After the war, many Allied nations acquired and operated Fokker D.VIIs, and production continued sporadically until the late 1920s. America, Soviet Russia and many Eastern European and Baltic countries operated the type, while Belgium and Switzerland used them into the 1930s.

Fokker D.VII 'U.10' of Jasta 65, now on display at the National Air and Space Museum, Washington DC

SOPWITH

WORDS **JACK GRIFFITHS**

'Pup' was initially a nickname due to the fighter's small size, but it stuck and later took over from the official 'Scout' title

SOPWITH PUP

ROLE:	SINGLE-SEAT FIGHTING SCOUT
YEARS IN SERVICE:	1916-17
LENGTH:	5.9M (19FT 3.75IN)
WINGSPAN:	8.1M (26FT 6IN)
MAXIMUM SPEED:	179.4KM/H (111.5MPH)
MAXIMUM ALTITUDE:	5,334M (17,500FT)
ENGINE:	59.65KW (80HP) LE RHONE ROTARY ENGINE
ARMAMENT:	VICKERS .303 MACHINE GUN, LEWIS MACHINE GUN (ON SOME MODELS), LE PRIEUR ROCKETS

PUP

Take a tour of the aircraft that brought the fight to the Germans and helped end the terror of the Fokker Scourge

The Pup was one of Sopwith's most iconic designs

"IT WAS A FIXED-GUN, SINGLE-SEAT FIGHTER AND ENTERED SERVICE IN 1916 TO TAKE THE WAR IN THE SKIES OF FRANCE BACK TO THE GERMANS"

***Above:** A Pup taking off from the battle cruiser HMS Repulse in the pre-aircraft carrier era*

The precursor to the Sopwith Camel and the SE5, the Pup was one of the Royal Flying Corps' (RFC) finest aircraft in the middle stages of World War I. It was not an original design, and its shape stems from its bigger brother the Sopwith 1½ Strutter, but it was instantly effective. The plane was a fixed-gun single-seat fighter and entered service in 1916 to take the war in the skies of France back to the Germans.

1,770 Pups were built in total, and were used extensively on the Western Front as aviation became an important part of warfare for the first time. The plane fast became a favourite among pilots due to its responsive controls and manoeuvrability, but was phased out in late 1917 as German fighters such as the Albatros DIII began to outclass it.

In the latter stages of the war the Pup was handed a new responsibility: protecting Britain from the threat of Zeppelin raids. Fitted with more-powerful engines, they helped shield the skies from the German Empire's bombing attacks under Operation Türkenkreuz. After the war, Pups acted as training craft for pilots in the newly created RAF. Today they remain an iconic aircraft, and a fond reminder of the nascent period of military aviation. Very few aircraft are remembered with such nostalgia.

The aircraft's wheels were often accompanied by skid undercarriages to aid landing

The cockpit, although basic looking, was more than enough to be effective on the Western Front

COCKPIT

The aircraft's original design was supposedly sketched out in chalk on a Kingston shop floor by test pilot Harry Hawker. Nevertheless, the Pup possessed flying qualities above many of its contemporaries. The control was smooth and the .303 Vickers machine gun was attached to an interrupter gear, so that it could be fired forward through the plane's propeller.

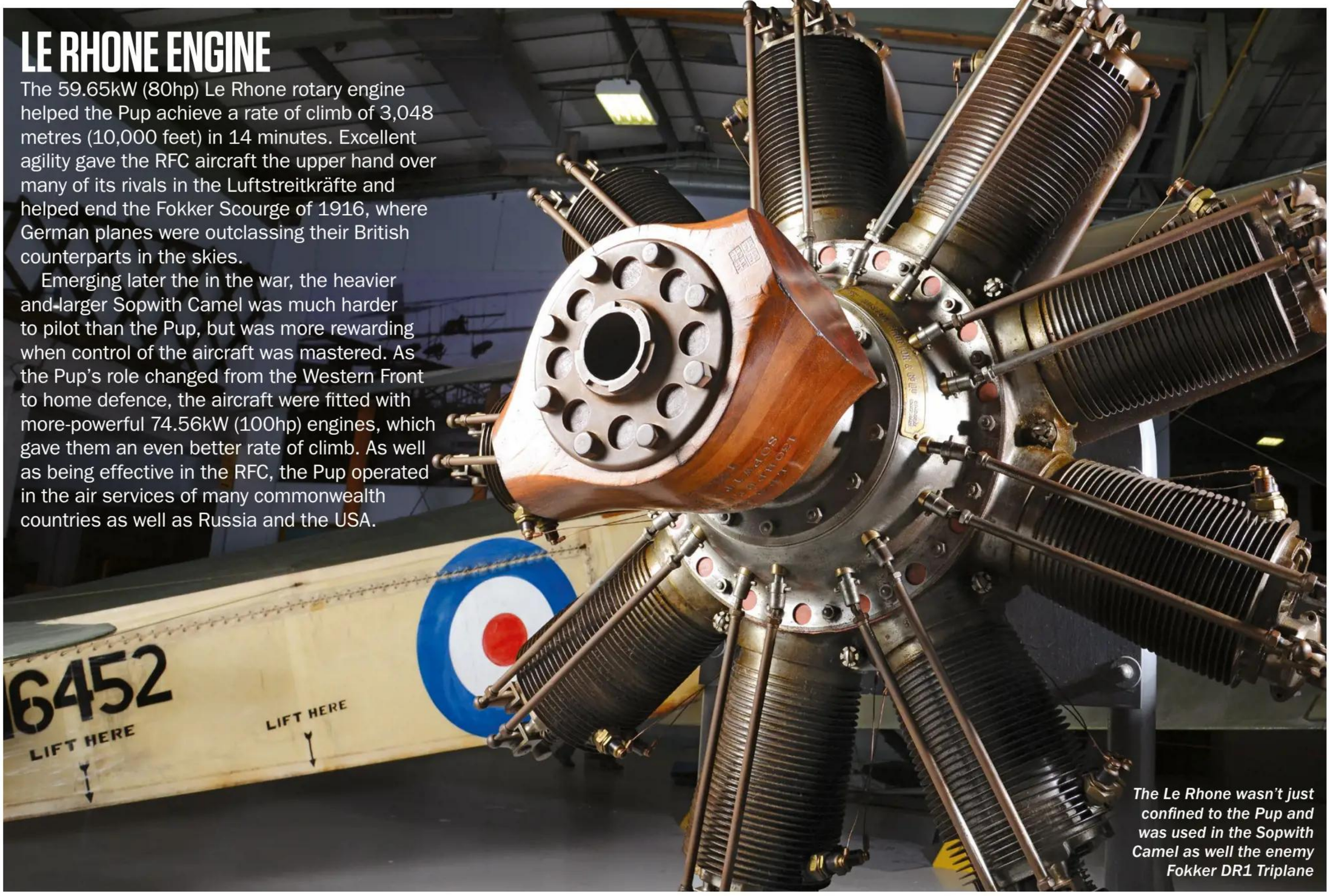
Overheating was a common problem found with Vickers guns, but holes were cut into the water jacket so air could cool the weapon faster. The simple design of the Pup, in its role as a fighter scout, became the template that later Sopwith variations would follow. In the early days of military aviation, new and upgraded prototypes were rolling off the production line at a rapid rate. As such, it wasn't long until the Pup was superseded by more-improved models that were poised to take to the skies over France.

"IN THE EARLY DAYS OF MILITARY AVIATION, NEW AND UPGRADED PROTOTYPES WERE ROLLING OFF THE PRODUCTION LINE AT A RAPID RATE"

LE RHONE ENGINE

The 59.65kW (80hp) Le Rhone rotary engine helped the Pup achieve a rate of climb of 3,048 metres (10,000 feet) in 14 minutes. Excellent agility gave the RFC aircraft the upper hand over many of its rivals in the Luftstreitkräfte and helped end the Fokker Scourge of 1916, where German planes were outclassing their British counterparts in the skies.

Emerging later the in the war, the heavier and-larger Sopwith Camel was much harder to pilot than the Pup, but was more rewarding when control of the aircraft was mastered. As the Pup's role changed from the Western Front to home defence, the aircraft were fitted with more-powerful 74.56kW (100hp) engines, which gave them an even better rate of climb. As well as being effective in the RFC, the Pup operated in the air services of many commonwealth countries as well as Russia and the USA.



The Le Rhone wasn't just confined to the Pup and was used in the Sopwith Camel as well the enemy Fokker DR1 Triplane

THE PRE-AIRCRAFT CARRIER AGE

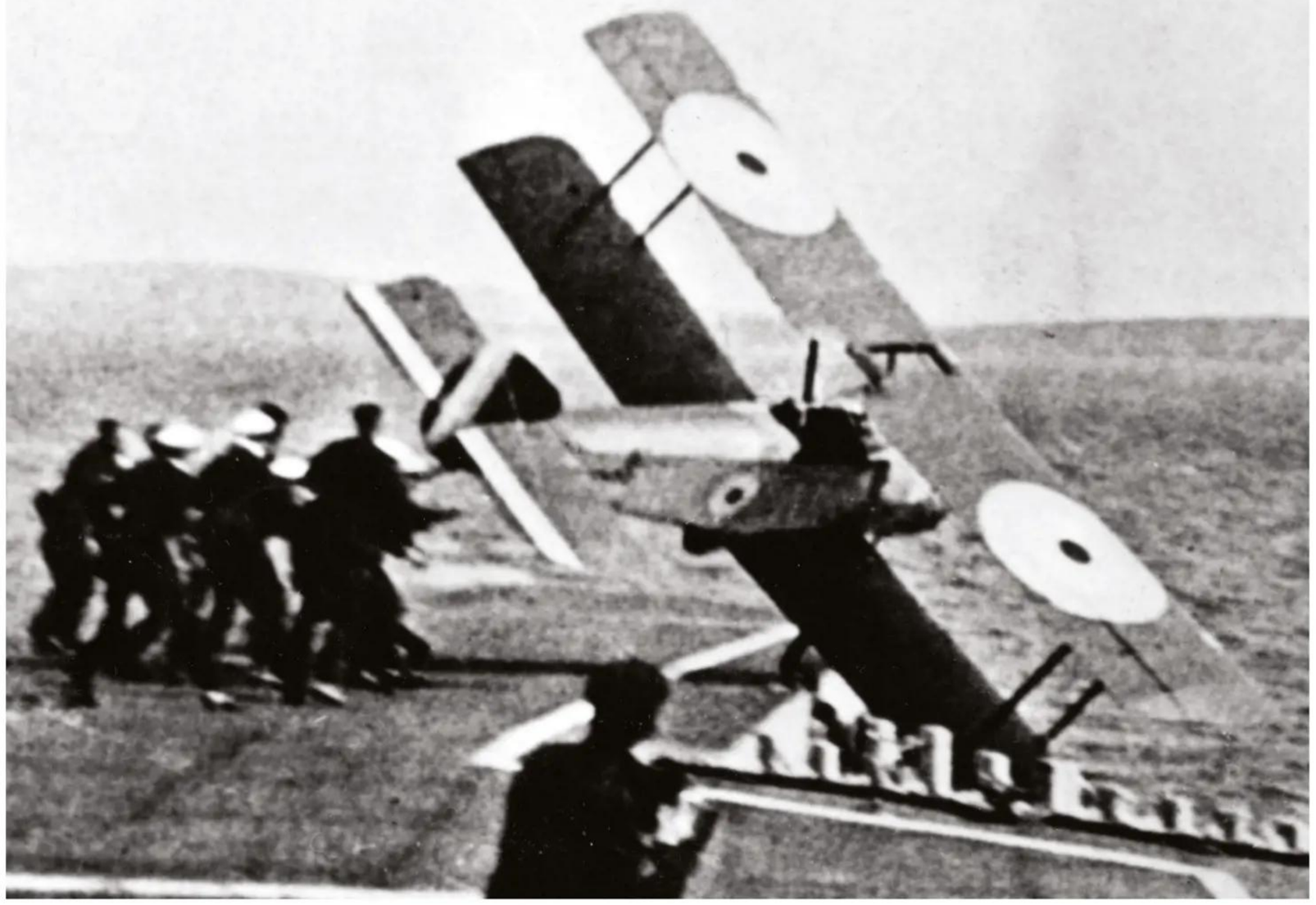
HOW THE PUP BECAME THE FIRST PLANE TO LAND ON A MOVING SHIP

As well as proving itself on the Western Front, the Sopwith Pup shot to fame with its excellent ability to land. Fitted with skid undercarriages, the fighter was designed to catch the traps set up on the decks of ships. On 2 August 1917, it became the first aircraft to achieve the feat when Lieutenant Commander Edwin Dunning successfully landed on the flying deck of battle cruiser HMS Furious.

Dunning was successful in landing at sea once again on 7 August, but he was not to be so lucky on his third attempt. As he approached the Furious, the engine choked and the lieutenant commander tried to pull out. However, it was too late, and the heavy landing burst a tyre as an updraft threw the plane overboard. Dunning was thrown about in the cockpit and knocked unconscious. He drowned in the sinking aircraft.

***Right:** Dunning's untimely death was shocking, but he had shown that landings could be made at sea, changing the face of aviation*

"FITTED WITH SKID UNDERCARRIAGES, THE FIGHTER WAS DESIGNED TO CATCH THE TRAPS SET UP ON THE DECKS OF SHIPS"



DESIGN

To aid visibility, a portion of the top wing's centre section was cut out. Each wing had ailerons and raked tips to help the control and stability of the Pup. The top speed and rate of climb was aided significantly by the light yet tough structure of the aircraft.

When the Pup was reassigned to defensive duties, extra armament was included on top of the standard Vickers gun. Four Le Prieur rockets were attached to either wing and fired at the zeppelins that were appearing over London. Due to their inaccuracy, none of the rockets managed to bring down a zeppelin outright, but they did inflict damage and were effective in grounding enemy observation balloons. The rockets were replaced by incendiary bullets towards the end of the war.

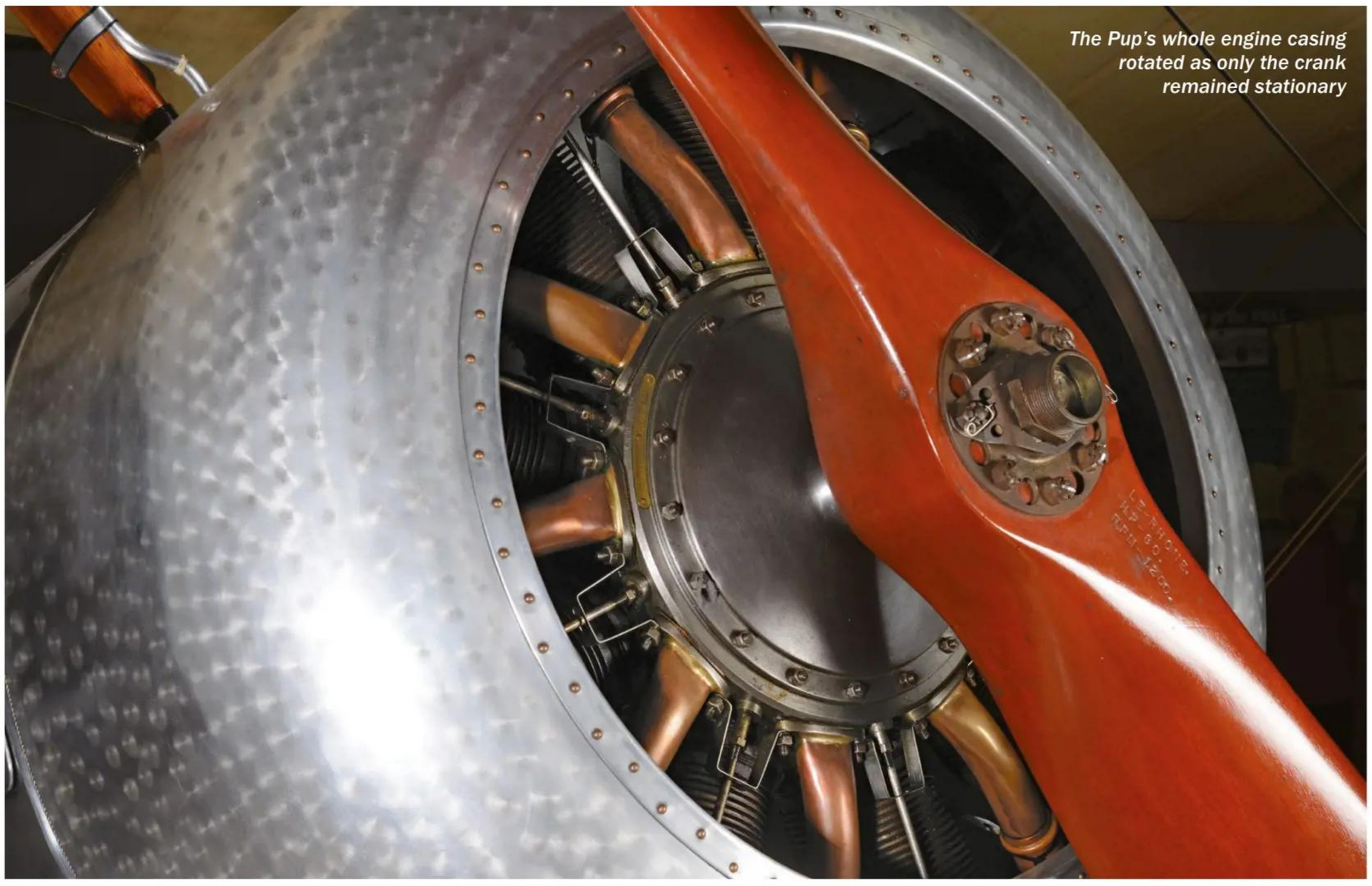
The Pup may look basic and a little flimsy, but it was tough and packed with the latest in aviation technology

A SOPWITH PUP PILOT

The uniform of an RFC pilot was based on comfort, protection and warmth. A thick leather overcoat and scarf were worn at all times to protect from the cold as well as chafing from the wind. Goggles and a flying helmet were a necessity in an open cockpit as all sorts of debris could fly into the pilot's face. Tough boots were also a must to withstand the wear and tear of piloting a Pup.

"GOGGLES AND A FLYING HELMET WERE A NECESSITY IN AN OPEN COCKPIT"

"THE TOP SPEED AND RATE OF CLIMB WAS AIDED SIGNIFICANTLY BY THE LIGHT YET TOUGH STRUCTURE OF THE AIRCRAFT"



The Pup's whole engine casing rotated as only the crank remained stationary

***Right:** A single-seat fighter, the Pup had a wooden frame covered in canvas*

THE SOPWITH ZOO

THE DOMINATION OF THE SOPWITH AVIATION COMPANY IN BRITAIN'S WAR IN THE SKIES

Founded by Thomas Octave Murdoch Sopwith, the aviation company started off small but soon grew into one of the chief designers of World War I aircraft. In just eight years the company employed 3,500 people in 14 acres of factories. 25 per cent of the British aircraft flown in World War I were Sopwith designs with 60 per cent of all single-seat aircraft being made by the company. After the war, Sopwith couldn't capitalise on its monopoly in the industry and failed to adjust to the lack of peacetime demand for fighter planes. By 1920, the company was no more.

***Above:** An experimental design, the Sopwith Triplane was only built in small numbers but was nevertheless effective against the German Fokkers*

***Above, right:** Equipped with two Vickers .303 machine guns and highly manoeuvrable, the Camel came into its own after coming into combat service in June 1917*

***Right:** The Strutter was a pioneering design and was the first British fighter to include a synchronised machine gun on board*

ALBATROS

The last, but perhaps least successful, of Germany's line of Albatros fighters during World War I

WORDS **STUART HADAWAY**

PROMINENT ENGINE
Large parts of the engine stood free of the cowling for ease of access, while metal panels around the nose were easily removed to facilitate maintenance.

BETTER VISIBILITY
The 'N'-shaped struts allowed the upper wing to be lower-set, giving the pilot a better view forward and above without losing structural strength.

WEAK POINT
The lower main spar was a notorious weak point on the D.V and D.Va, although moving it forward in the D.Va mitigated the problem to some extent.

D.VA

Image: Wiki / PD / Gov

Image: Wiki / PD / Gov

Manfred von Richthofen's Albatros D.V – he was not impressed by the design

ALBATROS D.VA

COMMISSIONED:	1917
ORIGIN:	GERMANY
LENGTH:	7.33M (24FT)
WINGSPAN:	9.05M (29FT 8IN)
ENGINE:	MERCEDES D.IIIA 127-138 KW (170-185HP)
CREW:	1
PRIMARY WEAPON:	2 X LMG08/15 SPANDAU 7.92MM (0.312IN) MACHINE GUNS

The Albatros Flugzeugwerke produced a line of Germany's most successful fighters from 1916 onwards. The D.I had regained air superiority from the British over the Somme in the autumn of 1916, soon supported by the improved D.II. The redesigned D.III followed in early 1917 and would be the mount most used by Manfred 'The Red Baron' von Richthofen, the highest-scoring ace of the war. The D.V was more drastically redesigned still, although it retained the distinctive Albatros streamlined fuselage and spade-like tailplanes.

However, when the D.V entered service in the early summer of 1917 it proved to have several serious flaws, including an underpowered engine and structural weakness in both upper and lower wings. The improved D.Va followed in the late summer, with a more powerful engine and other improvements, but it still never quite lived up to its promise. The Albatros D.Vs and D.Vas (as well as many older D.IIIs) formed the bulk of the German fighter force until the end of the war. They could hold their own in competent hands against the latest Allied fighters, but were not able to replicate the successes enjoyed in 1916 and early 1917.

Pilots of Jasta 2 pose with a D.Va

© Alamy

HARD-SKINNED FUSELAGE

While most contemporary aircraft were fabric-covered, the Albatros had a plywood skin over a frame of eight longerons to form a semi-monocoque structure.

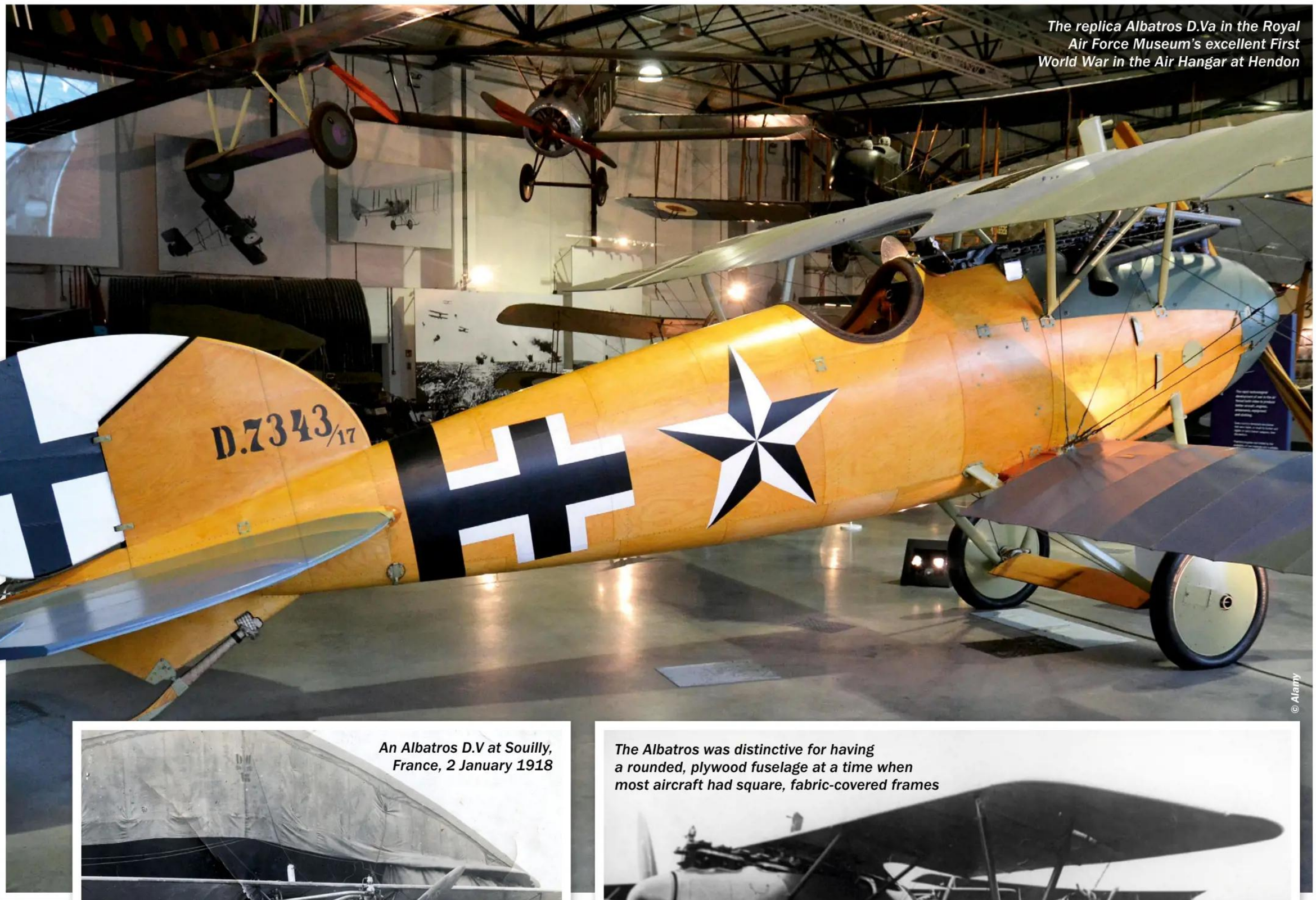
"ALBATROS FIGHTERS HAD A DISTINCTIVE LOOK, WITH SMOOTH, STREAMLINED PLYWOOD SEMI-MONOCOQUE FUSELAGES"

A pilot of JG26 in front of his Albatros, with the twin-Spandau guns clearly visible in front of the cockpit

The D.V of Fritz Jacobsen of Jasta 31, painted gaudily even by usual German standards

ARMAMENT

The Albatros D.V was equipped with two fixed LMG08/15 7.92mm (0.302in) machine guns, mounted on the cowling in front of the cockpit, and fired forwards through the propeller by means of a direct flexible drive interrupter gear to prevent bullets hitting the blades. The LMG08/15 was a stripped down and air-cooled version of the standard German army machine gun. Each gun was operated by a separate trigger and could be fired individually. It was belt-fed, with the empty belts being fed into drums for re-use, while spent cartridges were ejected overboard.

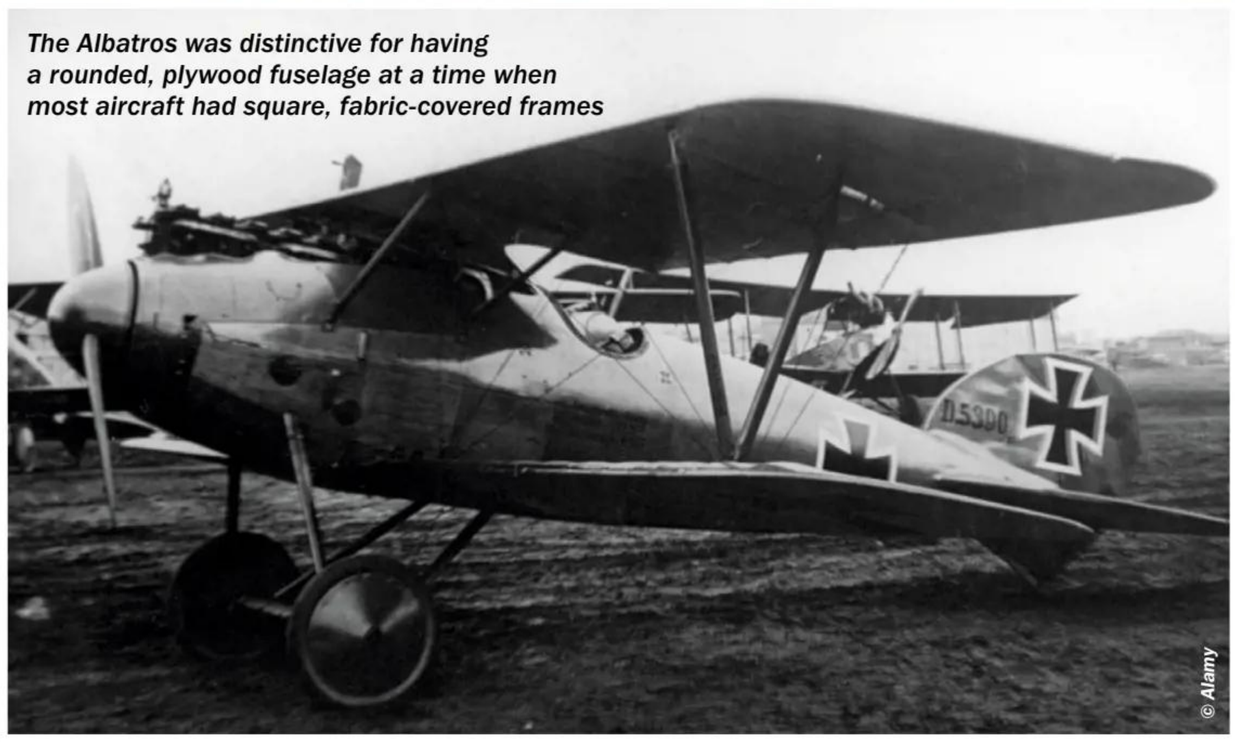


The replica Albatros D.Va in the Royal Air Force Museum's excellent First World War in the Air Hangar at Hendon

© Alamy

An Albatros D.V at Souilly, France, 2 January 1918

© Getty

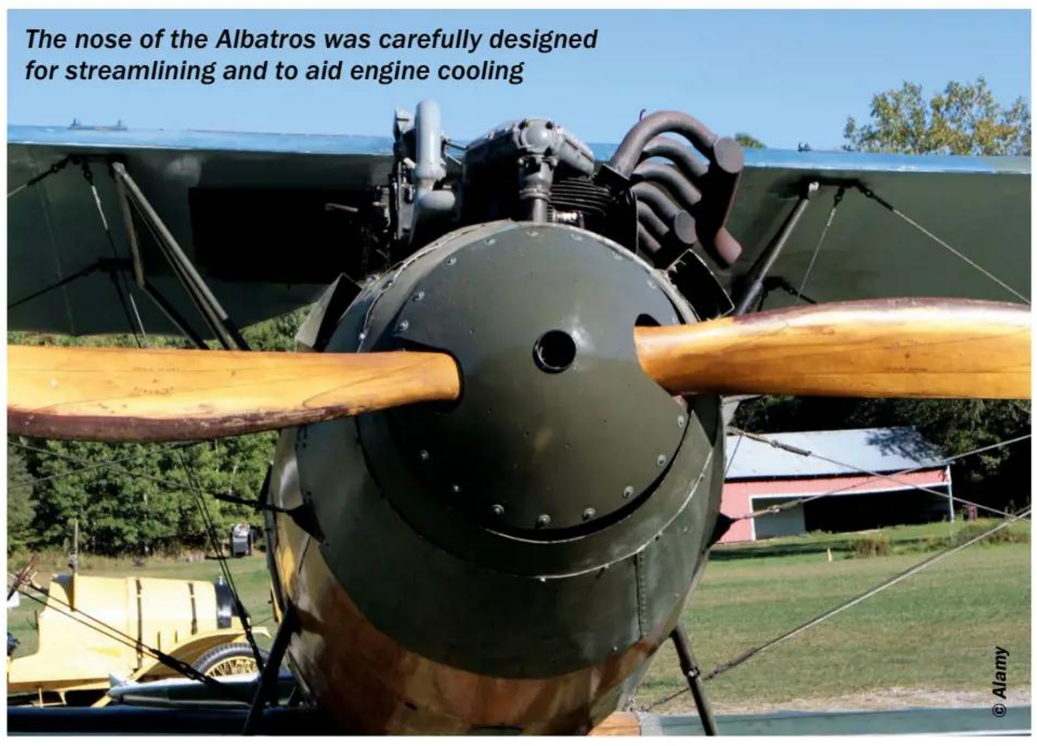


The Albatros was distinctive for having a rounded, plywood fuselage at a time when most aircraft had square, fabric-covered frames

© Alamy

DESIGN

Albatros fighters had a distinctive look, with smooth, streamlined plywood semi-monocoque fuselages. The D.V was more rounded than earlier models, which had flatter sides. The wings were wooden-framed and fabric-covered, and had two weaknesses. The tips of the upper wing were prone to cracking and folding, which was a problem but not fatal. More seriously, the main spar of the lower planes was prone to breaking in a dive, due to vibration rather than stresses. The cause took a long time to identify and was never fully rectified.



The nose of the Albatros was carefully designed for streamlining and to aid engine cooling

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ENGINE

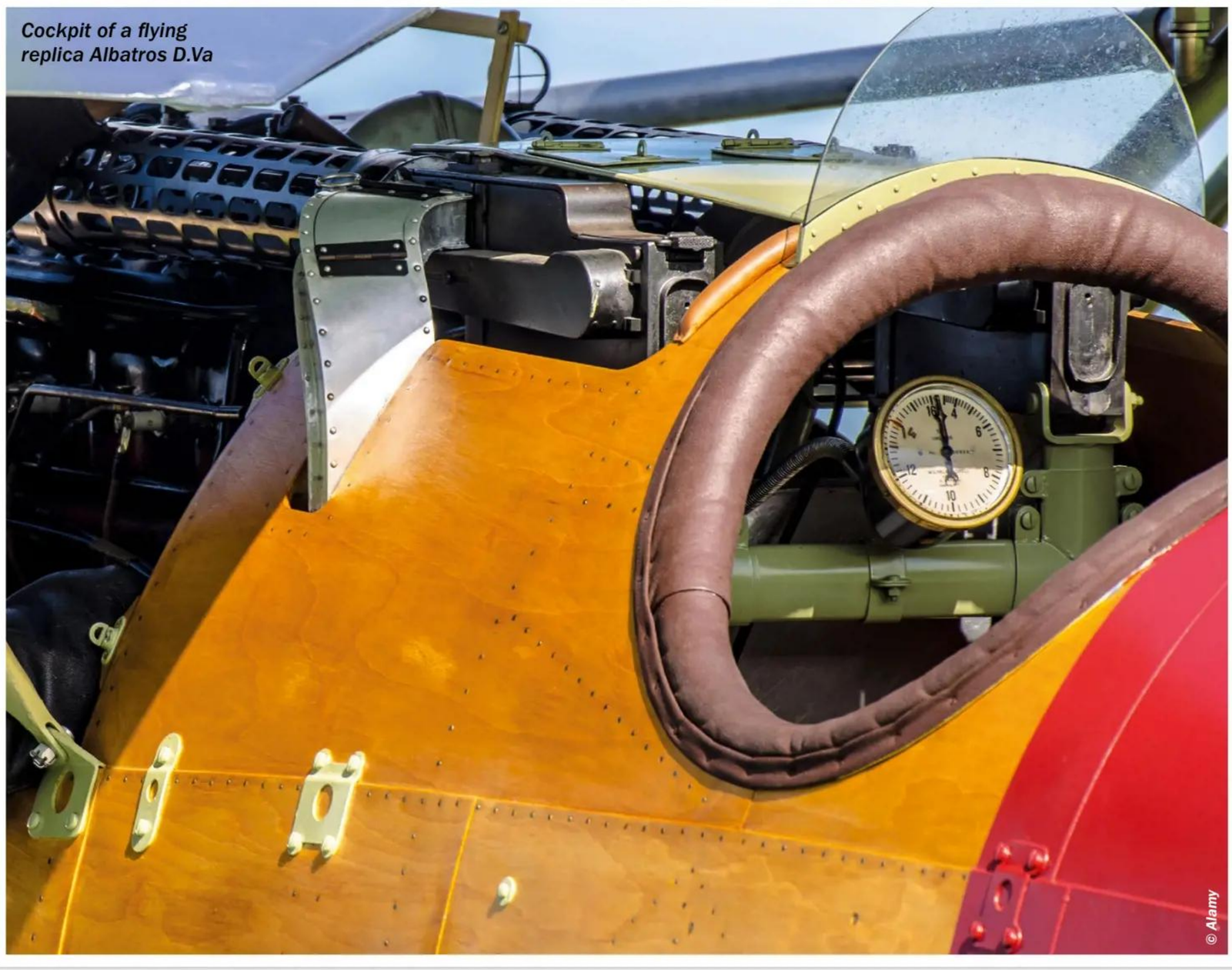
The D.V had a Mercedes D.III 120kW (160hp), but this was upgraded to the D.IIIa in the D.Va, with 127-138kW (170-185hp) obtained by raising the compression ratio and enlarging the cylinder and pistons. It was installed with much of the cylinder block exposed for ease of maintenance. A large spinner was fitted over the two-bladed propeller, for better aerodynamics. The spinner was also slightly smaller in diameter than the fuselage behind, allowing air to flow into the cowling and over the crankcase to aid cooling.

“MANFRED VON RICHTHOFEN DAMNED THE AIRCRAFT AS ‘SO OBSOLETE AND SO RIDICULOUSLY INFERIOR’”

Image: Wiki / PD / Roland Turner

Image: Wiki / PD / US

The sparse and functional cockpit of a D.V



Cockpit of a flying replica Albatros D.Va

© Alamy

COCKPIT

The cockpit of the Albatros was quite sparse even by World War I standards, with basic instruments being fitted in around the butts of the two Spandau machine guns, which jutted back in front of the pilot. The forward wall of the cockpit was formed by the main fuel tank. The throttle, on the left, worked by pulling back to accelerate, and the spade-handled control column was equipped with two separate triggers, one for each gun.

© Alamy

***Above:** A captured Albatros D.Va at El Affule aerodrome, Palestine, September 1918*

The Red Baron was scathing about the D.V's performance

Image: Wiki / PD / Library of Congress

SERVICE HISTORY

The Albatros D.V was commissioned in April 1917 and entered service the following month. However, it failed to live up to expectations, and in July Manfred von Richthofen damned the aircraft as "so obsolete and so ridiculously inferior". The designers responded with the D.Va, which was intended to fix the most blatant problems – lack of power (and thus speed and manoeuvrability), and certain structural weaknesses. The D.Va entered service in October 1917, but although better in some ways it was still mediocre overall. However, until the arrival of the Fokker D.VII in the spring of 1918 it was the best that the German flying services had, and formed the backbone of most fighter units. By April 1918, over 1,000 D.Vs and D.Vas were in service, but in that month production ceased and numbers gradually fell throughout the rest of the war as attrition took hold.

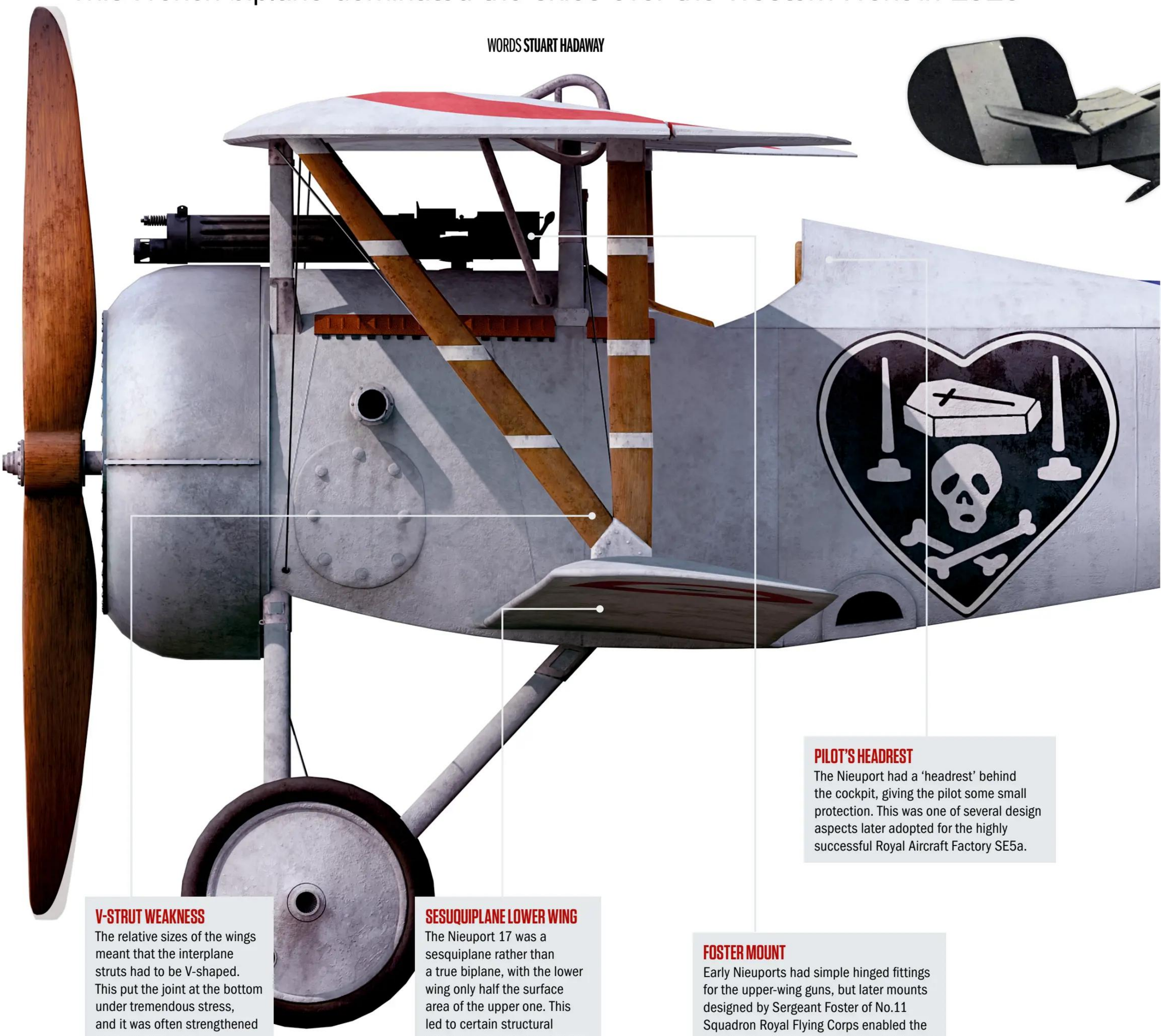
© Alamy

The D.Vas of Jasta 12 take off in France

NIEUPORT 17

This French biplane dominated the skies over the Western Front in 1916

WORDS **STUART HADAWAY**



V-STRUT WEAKNESS

The relative sizes of the wings meant that the interplane struts had to be V-shaped. This put the joint at the bottom under tremendous stress, and it was often strengthened when aircraft reached operational squadrons.

SESUQUIPLANE LOWER WING

The Nieuport 17 was a sesquiplane rather than a true biplane, with the lower wing only half the surface area of the upper one. This led to certain structural weaknesses, but gave better visibility and rate of climb.

PILOT'S HEADREST

The Nieuport had a 'headrest' behind the cockpit, giving the pilot some small protection. This was one of several design aspects later adopted for the highly successful Royal Aircraft Factory SE5a.

FOSTER MOUNT

Early Nieuports had simple hinged fittings for the upper-wing guns, but later mounts designed by Sergeant Foster of No.11 Squadron Royal Flying Corps enabled the pilot to pull the gun backwards on a rail for reloading, or fire to upwards.

The Nieuport was light, fast and manoeuvrable

© Alamy

NIEUPORT 17

COMMISSIONED:	1916
ORIGIN:	FRANCE
LENGTH:	5.8M (19FT)
WINGSPAN:	8.16M (26FT 9IN)
ENGINE:	82 KW (110HP) LE RHONE 9J
CREW:	1
PRIMARY WEAPON:	1 X 7.7MM (0.303IN) VICKERS OR LEWIS MACHINE GUN
SECONDARY WEAPON:	8 LE PRIEUR ANTI-BALLOON ROCKETS

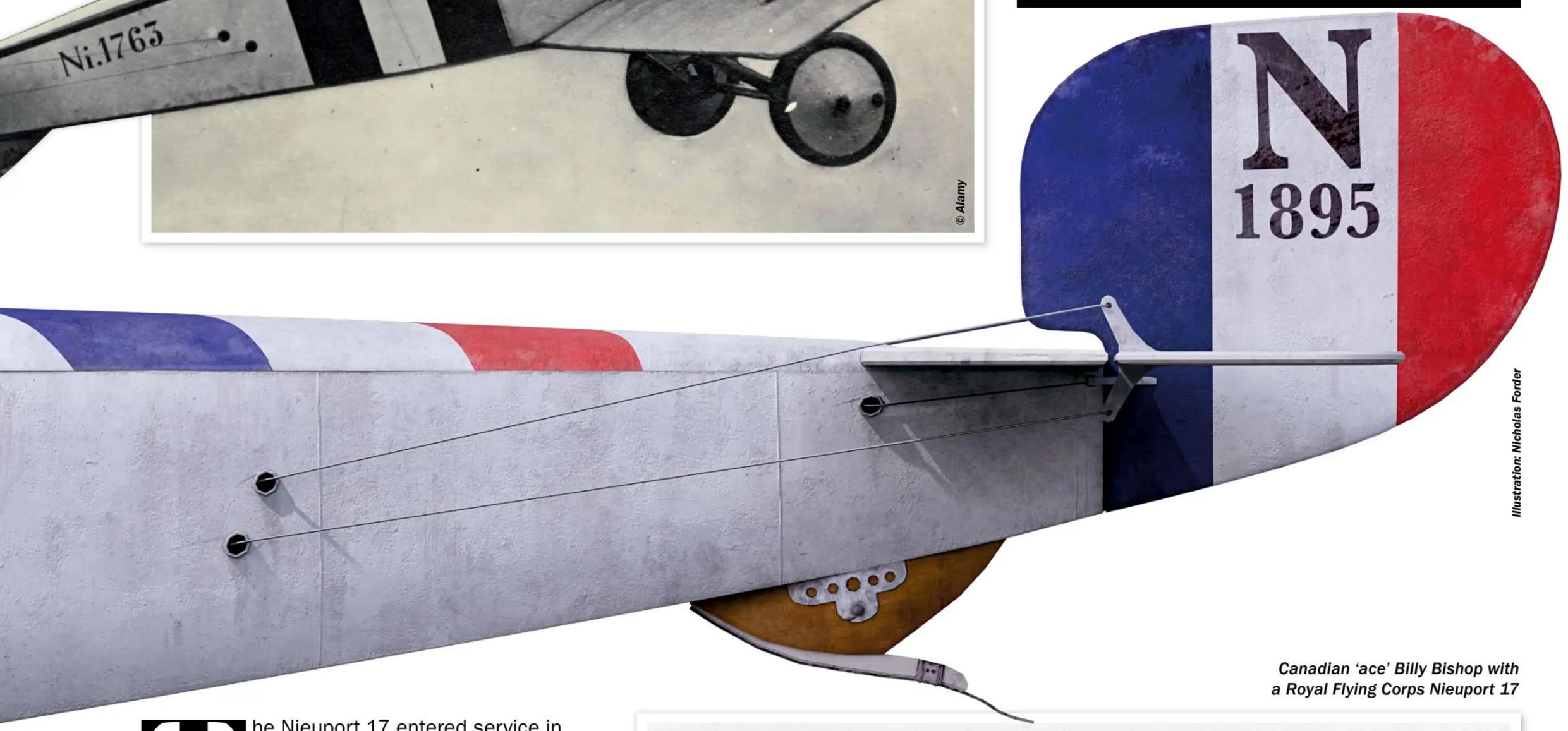


Illustration: Nicholas Forder

Canadian 'ace' Billy Bishop with a Royal Flying Corps Nieuport 17

The Nieuport 17 entered service in the spring of 1916, when the Entente air forces were on the back foot. The 'Fokker Scourge' had been ongoing for months, with the German Fokker Eindecker holding air superiority over the Western Front. Together with the British de Havilland DH2, the Nieuport 17 put an end to this domination, winning back air superiority for the British and French just in time for their flying services to play important roles in the Battle of the Somme over the summer. With speeds of up to around 160km/h (100mph) and great manoeuvrability, it was an excellent fighter even though lightly armed, and the type kick-started the careers of many aces, including Georges Guynemer, Charles Nungesser and Mick Mannock. Even into the spring of 1917, British ace Albert Ball VC preferred his old Nieuport 17 over his cutting-edge SE5a, often flying it alone looking for prey.

So successful was the type that the Germans even reverse-engineered several captured airframes. They built their own Nieuport 17s and operated them as the Siemens-Schuckert D.I from early 1917, although mostly as fighter trainers.

© Alamy

ARMAMENT

The standard French Nieuport 17 carried one 7.7mm (0.303in) Vickers machine gun on the cowling before the cockpit. However, the British and Italians preferred a 7.7mm (0.303in) Lewis Gun mounted above the upper wing. This was problematic, being hard to aim (it was not parallel to the line of flight) and hard to change the drums to reload, but despite this the Lewis Gun was also used by some French pilots. Eight Le Prieur anti-balloon rockets could also be carried, mounted on the outside of the outer inter-wing struts.

***Right:** A Nieuport fitted with Le Prieur anti-balloon rockets; metal plates protected the lower wing from scorching*

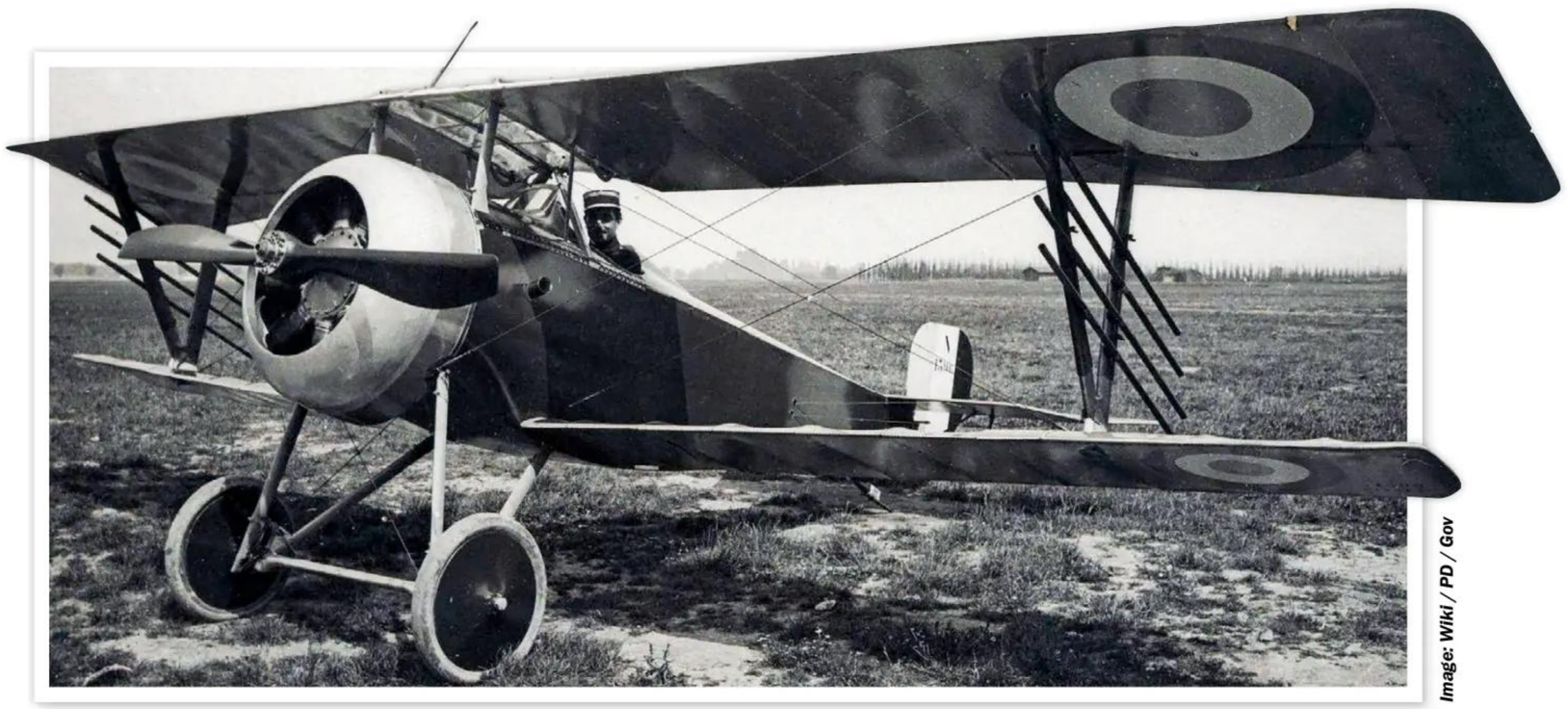


Image: Wiki / PD / Gov

The Lewis Gun on the upper wing would have to be pulled back towards the pilot in order for him to change the drum magazine

Image: Wiki / PD / Gov

The interrupter gear on the Nieuport 17 was modified in later models, shifting the gun to one side

© Alamy

***Above:** A partially dismantled Nieuport 17*

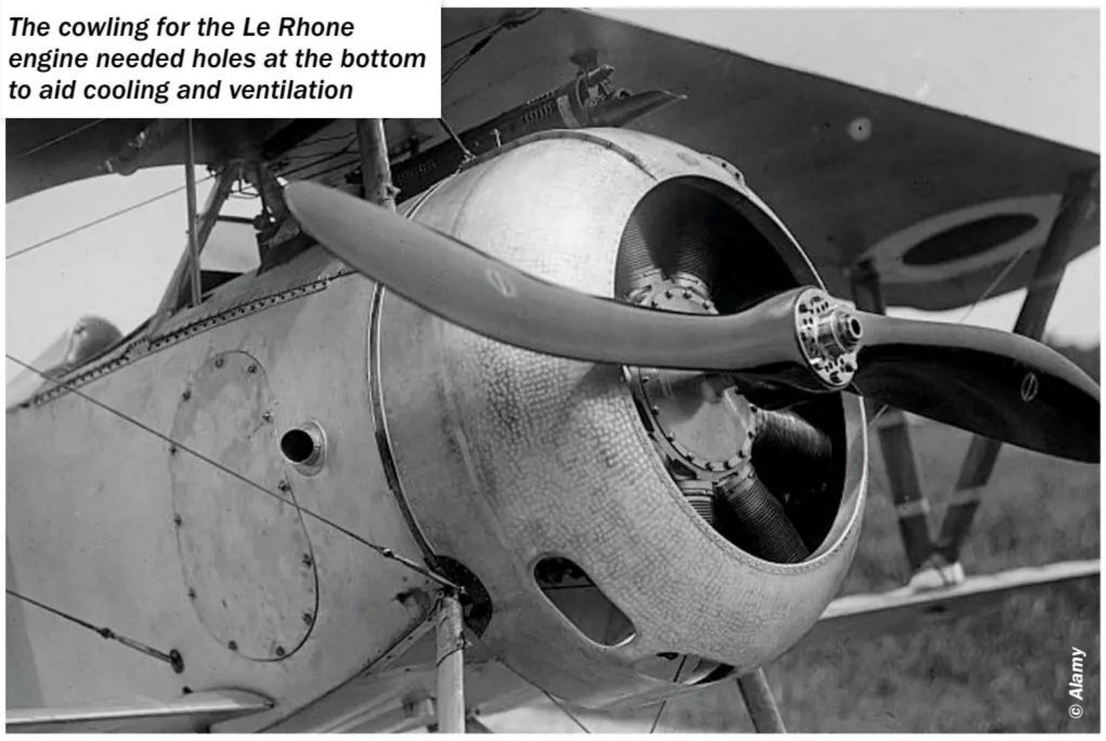
A replica Nieuport 17, clearly showing the sesquiplane wing design

"EIGHT LE PRIEUR ANTI-BALLOON ROCKETS COULD ALSO BE CARRIED, MOUNTED ON THE OUTSIDE OF THE OUTER INTER-WING STRUTS"

DESIGN

The Nieuport 17 had a mostly wooden framework construction, covered in stiffened fabric. The fuselage was rectangular at the front, tapering off to a trapezoid to the rear. The tail was strengthened by having a light metal framework, and the nose forward of the cockpit was aluminum-skinned. The type was a sesquiplane, meaning the lower wing had half the surface area of the upper wing. This meant that only the upper wing had ailerons, and also left the lower wing relatively weak and prone to structural failure under stress.

The cowling for the Le Rhone engine needed holes at the bottom to aid cooling and ventilation



ENGINE

Nieuport 17s had a Le Rhone 9J 82 kW (110hp) rotary engine, or occasionally the similarly rated (and more basic but more expensive) Clerget engine. Both were air-cooled engines, held within a metal cowling with gaps cut into it to aid cooling and allow exhaust fumes to escape. The 9J was considered reliable and several are still flying in vintage or replica aircraft around the world. Later some aircraft were fitted with Le Rhone 97kW (130hp) rotaries, with this more powerful type being dubbed the Nieuport 17bis.

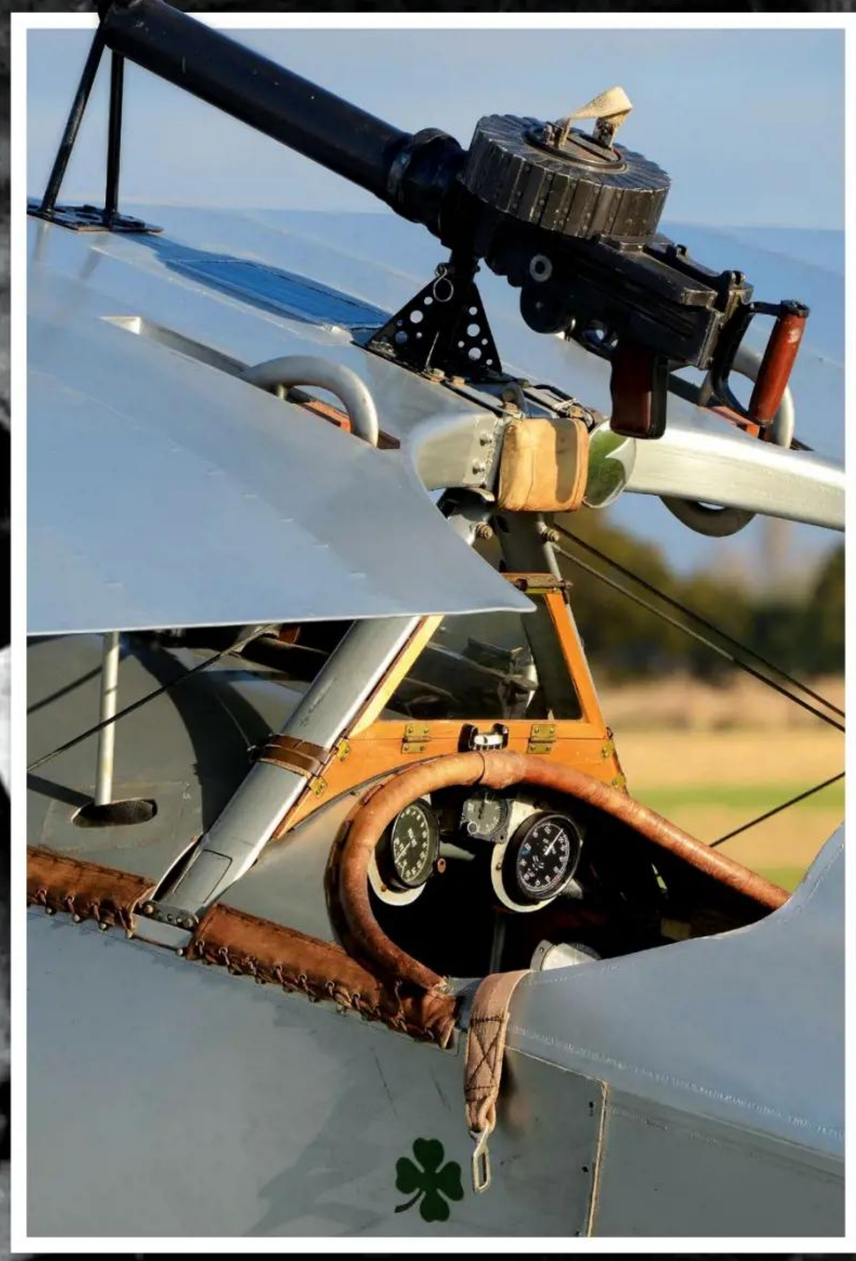
COCKPIT

The Nieuport 17 was unusual in having no instrument panel. Instead, instruments and flight controls were attached to the fabric of the airframe at points around the cockpit. This was rectified in the aircraft used by the British, with panels inserted and the instruments arranged into a more formal pattern. The pilot had a good view, with the sesquiplane lower wing allowing an unobstructed line of sight in front and below. The pilots eyes were in line with the upper wing, giving a good upward view as well.

The Nieuport 17 was a compact aircraft, with correspondingly cramped cockpit

This replica Nieuport 17 follows the British model for having a proper instrument panel

Around 3,600 Nieuport 17s were built, and several countries operated the type into the 1920s



SERVICE HISTORY

The Nieuport 17 entered service with the French flying services in May 1916, and with the British in July of the same year. The new aircraft was an instant success in combat on the Western Front and production of it was rapidly increased, while the naval air services of both countries also adopted the type. Fast and highly manoeuvrable, it was quickly adopted by the other Entente powers too. When the United States entered the First World War in 1917 they also acquired Nieuport 17s, not least because the type was already in use with the American volunteers who were flying in the French Escadrille Lafayette.

In early 1917 the type began to fall behind the newer German fighters that were entering the battle for air domination, but remained in British and French service into late 1917. It also remained in extensive service worldwide. Around 3,600 were built in France or under licence in Britain, Russia and Italy. Japan, Finland, the Netherlands, Switzerland, Belgium and various South American and eastern European countries all operated the type, many of them into the 1920s.

An Italian squadron of Nieuport 17s

A French Nieuport 17 captured by Germans in the autumn of 1916

“THE GERMANS REVERSE-ENGINEERED THE NIEUPORT 17 FROM A CAPTURED MODEL AND ENTERED A MODIFIED VERSION INTO THEIR OWN SERVICE”

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WWII

SPITFIRE SM520

44 The iconic British aircraft of the Second World War

MITSUBISHI A6M 'ZERO'

52 Japan's legendary fighter

DE HAVILLAND DH98 MOSQUITO

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MESSERSCHMITT BF 109G

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NORTH AMERICAN P-51 MUSTANG

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HAWKER HURRICANE

76 The early WWII aircraft that lives on in British memory

MESSERSCHMITT ME 262

82 The world's first operational jet fighter, even if it was a bit lacklustre

SPITFIRE

The two-seater version of a TR9, this Spitfire helped train future pilots for the perils of airborne warfare

WORDS **JACK GRIFFITHS**

The Spitfire is almost ubiquitous when discussing Britain's war in the skies during War World II. There were 22 different versions of the classic interceptor fighter built during the height of its time in the RAF. One of these was the SM520, a two-seater based on the TR9 model, which itself came from a Spitfire Mk IX.

The conversion from one to two seats was a post-war program, with the first SM520 arriving in 1948. The project helped provide flight and gunnery practise for new recruits to the RAF, such as the Irish Air Corps (IAC) Seafire fleet and many other air forces in what was to become the Commonwealth of Nations.

This particular model was constructed as a one-seater TR9 in a West Bromwich factory and was first delivered to the RAF in November 1944. As the war came to an end, the fighter was part of the mass RAF disarmament measures and sold to the South African Air Force (SAAF) for £2,000.

In Africa, it helped train pilots who were to be sent to the conflict in Korea and prepared them for flying in the American-made SAAF P-51 Mustangs. After a series of changes in ownership, the single-seat SM520 was converted to a two-seater in 2002, renamed G-ILDA (after a previous owner's granddaughter) and passed on to the Boultbee Flight Academy, where it is currently located.

The original British paint scheme was revived and it is now in a camouflage grey/green scheme as seen on the European Standard Day Fighters that helped Britain defend its borders in its hour of need.

SPITFIRE SM520

YEARS BUILT:	1948-51
LENGTH:	9.58M (31FT 5IN)
WINGSPAN:	11.23M (36FT 10IN)
MAXIMUM SPEED:	644KM/H (400MPH)
RANGE:	724KM (450 MILES)
ENGINE:	ROLLS-ROYCE / PACKARD MERLIN 266
CREW: INSTRUCTOR)	2 (STUDENT AND
ARMAMENT:	2 X .303 BROWNING MACHINE GUNS

SM520

The enduring Spitfire design means it is the only Allied fighter built during the war that was used until the 1950s. More than 20,000 were built in total

***Above, right:** This MK IIa P7350 is the only Spitfire that fought in the Battle of Britain and is still airworthy*

SM520 owned by the Boultbee Flight Academy

“AS THE WAR CAME TO AN END, THE FIGHTER WAS PART OF THE MASS RAF DISARMAMENT MEASURES AND SOLD TO THE SOUTH AFRICAN AIR FORCE (SAAF) FOR £2,000”

Pilots of the 611 West Lancashire Squadron launching a Spitfire off Biggin Hill Airport in 1942

COCKPIT

The aircraft that embodies the spirit and resolve of the British in the summer of 1940 is remarkably easy to pilot. Simple to start, the Merlin engine nearly always fired after two blades and was very reliable with each and every cockpit virtually identical and compact. Pilots past and present have commented favourably on its ease of handling as well as the iconic sound of its engine. As with many aircraft of the era, the Spitfire became harder to control when it neared its top speed. However, its light control column allowed it to be more manoeuvrable than its rival, the Messerschmitt Bf 109. During the Battle of Britain. It would often turn out of dives much quicker than its German equivalent. Without powered controls, these turns were achieved by the strength of the pilot's muscles alone.

The cockpit of the SM520 is authentic, down to the spade-like control column and the throttle control on the sidewall

Unlike the Messerschmitt, the Spitfire never took to the use of cannon and relied on its dual machine guns

BROWNING ARMAMENT

During the summer of 1940, the RAF had a foolproof plan against the oncoming Luftwaffe. The Hurricanes would go after the German Junker 87 and 88 bombers while the Spitfires would face off against the fighters. This decision was tailor made for the RAF aircraft, as the guns on the Spitfire were positioned narrower than those on the Hurricane, making it easier to engage the Messerschmitt fighters.

At its full capacity, the Spitfire could have eight Browning machine guns each containing 300 bullets. This sheer amount of ammo at a pilot's disposal meant even those with poor aim could at least hit something. These projectiles ranged from standard to tracer and incendiary to armour-piercing. The incendiary rounds in particular were very effective, as the RAF pilots targeted the fuel tanks of the Luftwaffe and blew Messerschmitts out of the sky.

When not in use, the opening of the machine gun's barrel was taped over to prevent the mechanism from freezing at high altitudes

THE MESSERSCHMITT BF

INSIDE THE SCOURGE OF THE SPITFIRE AND THE LUFTWAFFE'S BACKBONE

Fresh from its preparation in the Condor Legion in the Spanish Civil War, the Luftwaffe's Messerschmitts were ready to take the battle to the British over the Channel. 33,000 were made in total during the war and it provided the spine of the Luftwaffe fleet. Unlike the Spitfire, the Messerschmitt only had two machine guns, but these contained magazines of 1,000 rounds each.

They also had two 20mm cannons, which were useful against bombers but struggled to cope with the manoeuvrability of Spitfires and Hurricanes. Its main Achilles' heel was its short range, which prevented it from doing more damage across the Channel. Despite its loss in the Battle of Britain, the Bf 109 shot down the most Allied planes in the war and the design was taken on in 1947 by the new state of Israel. Its longevity was down to its simple and direct design, and it was still frequently used even in the later years of the war when the jet-powered Me 262 came into production.

Serving across all fronts and in all theatres, the Bf 109 was integral to the Nazi war machine

EMBLEMS AND DESIGN

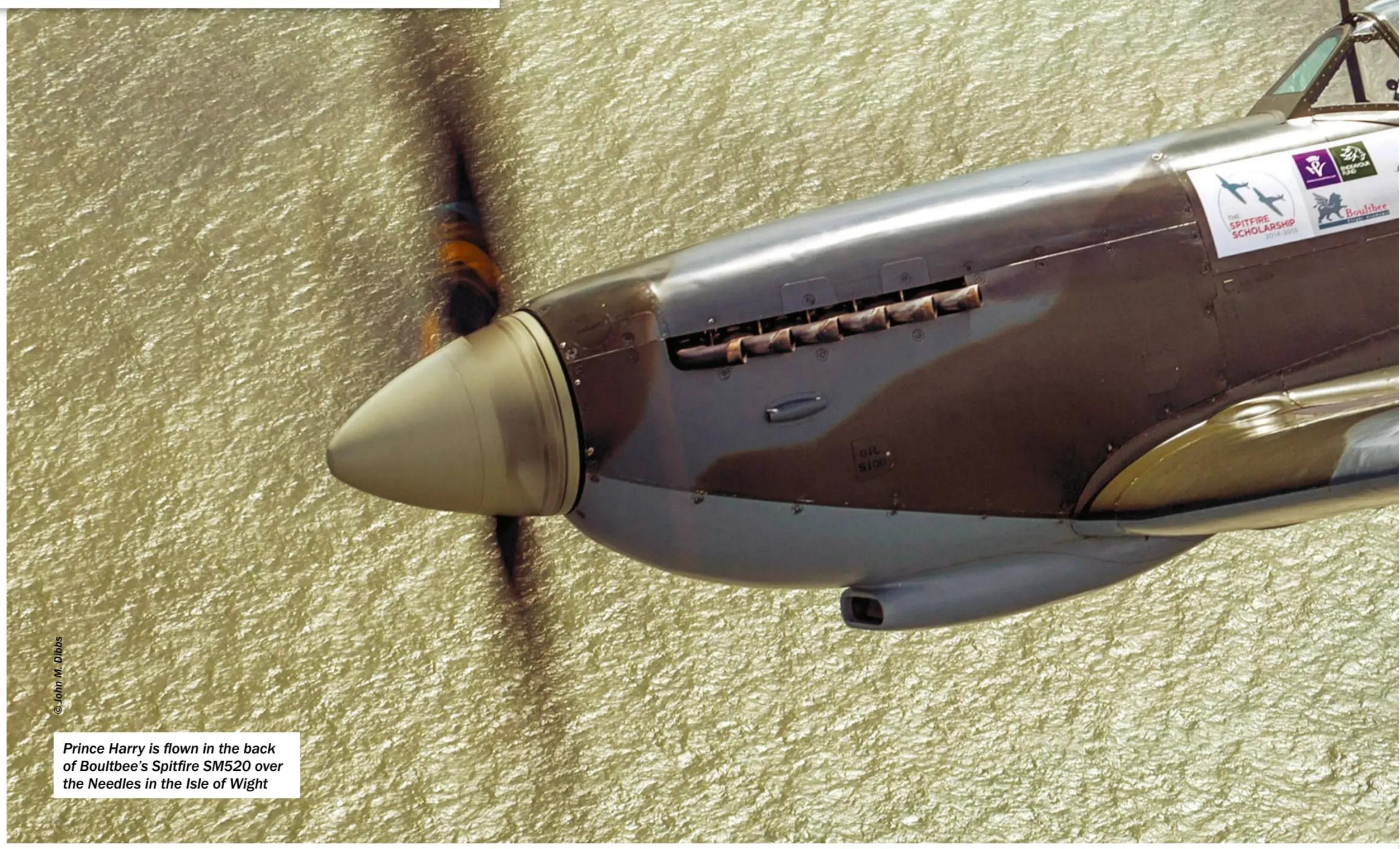
With its origins in World War I, the RAF roundel was used to identify British planes from the ground and in the heat of a dogfight. The Union Flag was initially put forward but due to its likeness to the German cross, the roundel was incorporated.

The first Spitfires were painted brown and dark green while the underside fuselage was white to allow for easy identification by anti-aircraft guns and reduce friendly fire. As the fight against the Luftwaffe began to spread to the Channel, the paint scheme changed from brown to grey as the new colour blended in with the dark sea.

This colour scheme was employed from then on with the odd variation. These included pink or dark blue for reconnaissance missions at low and high levels respectively and light brown for Middle East missions. Even the roundel was dropped, as in operations over Japan it was deemed too similar to the red disk Hinomaru emblem of the Japanese Zeros.

On the SM520, part of the engine has been moved to make way for the second cockpit in a modern redesign

***Above:** After the Battle of Britain, the Spitfire took on more of a reconnaissance role and was even occasionally painted pink to add to its camouflage*



© John M. Dibbs

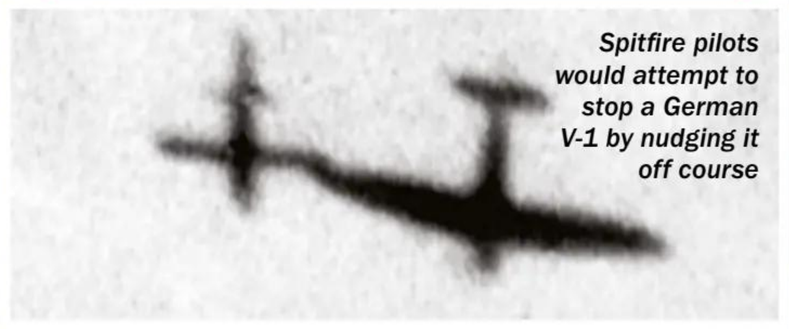
Prince Harry is flown in the back of Boultbee's Spitfire SM520 over the Needles in the Isle of Wight

“PILOTS PAST AND PRESENT HAVE COMMENTED FAVOURABLY ON ITS EASE OF HANDLING AS WELL AS THE ICONIC SOUND OF ITS ENGINE”

ADLERTAG

On 13 August 1940, better known as Adlertag or ‘Eagle Day’, the Luftwaffe appeared over the skies of Kent and Sussex, beginning the Battle of Britain. The Spitfire is famous for Britain’s resounding victory, but in the following months and years, the RAF and the Luftwaffe jostled for air supremacy.

The constantly updated Messerschmitts actually began to outperform the Spitfire by 1941, but the British clawed back the advantage with the development of the better and faster engines in the Spitfire IX. With this new power system, the Spitfires and Seafires had a much broader role in the RAF and Royal Navy. The improved models could now take down V-1 rockets before they hit their target, saving many lives and cities in southern England.



Spitfire pilots would attempt to stop a German V-1 by nudging it off course

"THE ENGINE WAS SO GOOD THAT BOTH THE SPITFIRE AND THE HURRICANE WERE BUILT TO ACCOMMODATE IT"

SPITFIRE VS HURRICANE

WHICH BATTLE OF BRITAIN MACHINE WAS THE SUPERIOR FIGHTER CRAFT?

The engine was a good all-rounder and was also used in Lancaster bombers, Hurricanes and the USAAF P51 Mustang

THE MERLIN ENGINE

THE POWERHOUSE BEHIND THE SPITFIRE'S ICONIC SOUND

Despite being used in more than 40 aircraft during World War II, the Merlin is most commonly associated with the Spitfire. Named after the bird of prey, the engine first took to the skies in February 1935 and was a marked improvement on the previous Rolls Royce instalment, the Kestrel.

The engine was so good that both the Spitfire and the Hurricane were built to accommodate it. As efficient as it was, the Merlin wasn't without its faults. Unlike the engines of German Messerschmitts, the Merlin wasn't fuel-injected, so there was a danger of it cutting out in steep dives.

However, this was mostly fixed in 1941 by the addition of a new diaphragm in the engine's float chamber. This was affectionately known as the 'Miss Shilling's Orifice' after its designer Tilly Shilling. Even after World War II the Merlin was still in assembly, and production only ceased in 1950 after 150,000 had been made to help Britain win the war.

The Spitfire was very nearly called the 'Shrew', which wouldn't have been quite as intimidating

SUPERMARINE SPITFIRE

- ★ **MAXIMUM SPEED** 608KM/H (378MPH)
  RATE OF CLIMB 812M (2,665FT) PER MIN
  CEILING 10,668M (35,000FT)
- ★ **ARMAMENT** 2 X 20MM HISPANO MK II CANNONS
  4 X .303 CAL BROWNING MACHINE GUNS & 2 X 240LB BOMBS
- ★ **LONGEVITY** 1938-48 (20,351 MADE)

★★★

HAWKER HURRICANE

MAXIMUM SPEED 547KM/H (340MPH)
RATE OF CLIMB 847M (2,780FT) PER MIN ★
CEILING 10,972M (36,000FT) ★
ARMAMENT 4 X 20MM HISPANO MK II CANNONS
2 X 250LB BOMBS OR 1 X 500LB BOMB
LONGEVITY 1937-44 (14,583 MADE)

★★

The Hawker Hurricane served in all major theatres of World War II

Images: Alamy, Boultbee Flight Academy, Getty

MITSUBISHI

WORDS **STUART HADAWAY**

Japan's legendary carrier fighter distinguished itself in WWII's Pacific theatre

LIMITED PUNCH
The Zero's light construction left it unable to carry heavy armament, although later models had a further machine gun added to each wing.

IMPRESSIVE FUEL TANKS
Between the main fuel tank behind the engine, the tanks in either wing stub, and the optional drop tank, the Zero had a much longer range than other contemporary fighters.

Work began on the Mitsubishi A6M in 1937 as a carrier-based fighter for the Imperial Japanese Navy Air Service. It entered service in 1940 (the year 2600 in the Japanese calendar) and was officially designated the Navy Type 0. This led to the nickname 'Reisen', or 'Zero'. Although the Allies would later officially designate it the 'Zeke' in their reporting system, the name 'Zero' largely stuck on both sides.

On entering service, the fast and highly manoeuvrable Zero quickly gained a truly formidable reputation, easily out-flying anything sent against it in the skies over China. In late 1941 its arena spread to the Pacific, and again it dominated the skies against its British and American contemporaries. However it did not take long for the Allies to work out the Zero's strengths and weaknesses, and how to use them.

Instead of dogfighting, quick firing passes were adopted, while the heavier construction and fire-power of the Grumman Hellcats and Wildcats and Vought Corsairs allowed them to soak up the relatively light firepower of the A6M while delivering blows that were devastating to the Zero's light construction. Even so, the Zero remained a mainstay of the Japanese Navy until the very end of the war.

A6M ‘ZERO’

“ON ENTERING SERVICE THE FAST AND HIGHLY MANOEUVRABLE ZERO QUICKLY GAINED A TRULY FORMIDABLE REPUTATION”

CARRIER TAILHOOK
The Zero had a retractable tailhook for carrier landings. The tail wheel was also retractable.

FOLDING WINGS
Most Zero models had folding wing tips to facilitate movement and storage on cramped aircraft carriers.

MITSUBISHI A6M ‘ZERO’

COMMISSIONED:	1937
ORIGIN:	JAPAN
LENGTH:	9.06M (29FT 9IN)
WINGSPAN:	12M (39FT 4IN)
RANGE:	1,870KM (1,160 MILES)
ENGINE:	1 X NAKAJIMA NK1C SAKAE-12 14-CYLINDER AIR COOLED RADIAL ENGINE
CREW:	1
WEAPONS:	2 X 7.7MM (0.303IN) TYPE 97 MACHINE GUNS AND 2 X 20MM (0.787IN) TYPE 99-1 MK 3 CANNON

Illustration: Alex Pang

The Zero packed a light punch for its time, and by 1943 it was woefully outgunned

ARMAMENT

The Zero was armed with 2 x 7.7mm (0.303in) Type 97 machine guns in the cowling over the engine, firing through the propeller and supplied with 500 rounds per gun, and 2 x 20mm (0.787in) Type 99-1 cannon in the wings, each with 60 rounds (increased to 100 rounds from 1941). The armament was relatively light, and proved inadequate against later American carrier fighters. A small load of 2 x 60kg (130lb) bombs could be carried, or a fixed 250kg (550lb) bomb for kamikaze attacks late in the war.

In late 1944, desperation drove the Japanese to use the Zero as a kamikaze flying bomb

A restored Nakajima Sakae NK1C

ENGINE

Made by the Nakajima Aircraft Company, the Sakae ('Prosperity') was a twin-row 14-cylinder air-cooled radial engine. The type was used by the Imperial Japanese Navy Air Service as the NK1, with four models (the Zero used the 'C') used on a range of aircraft. The Imperial Japanese Army Air Force also used it for single and twin-engine aircraft as the 'Ha' series. It was rated at 700 kW (940 hp) for take-off and 710 kW (950 hp) at an operational height of 4,200 m (13,800 ft).

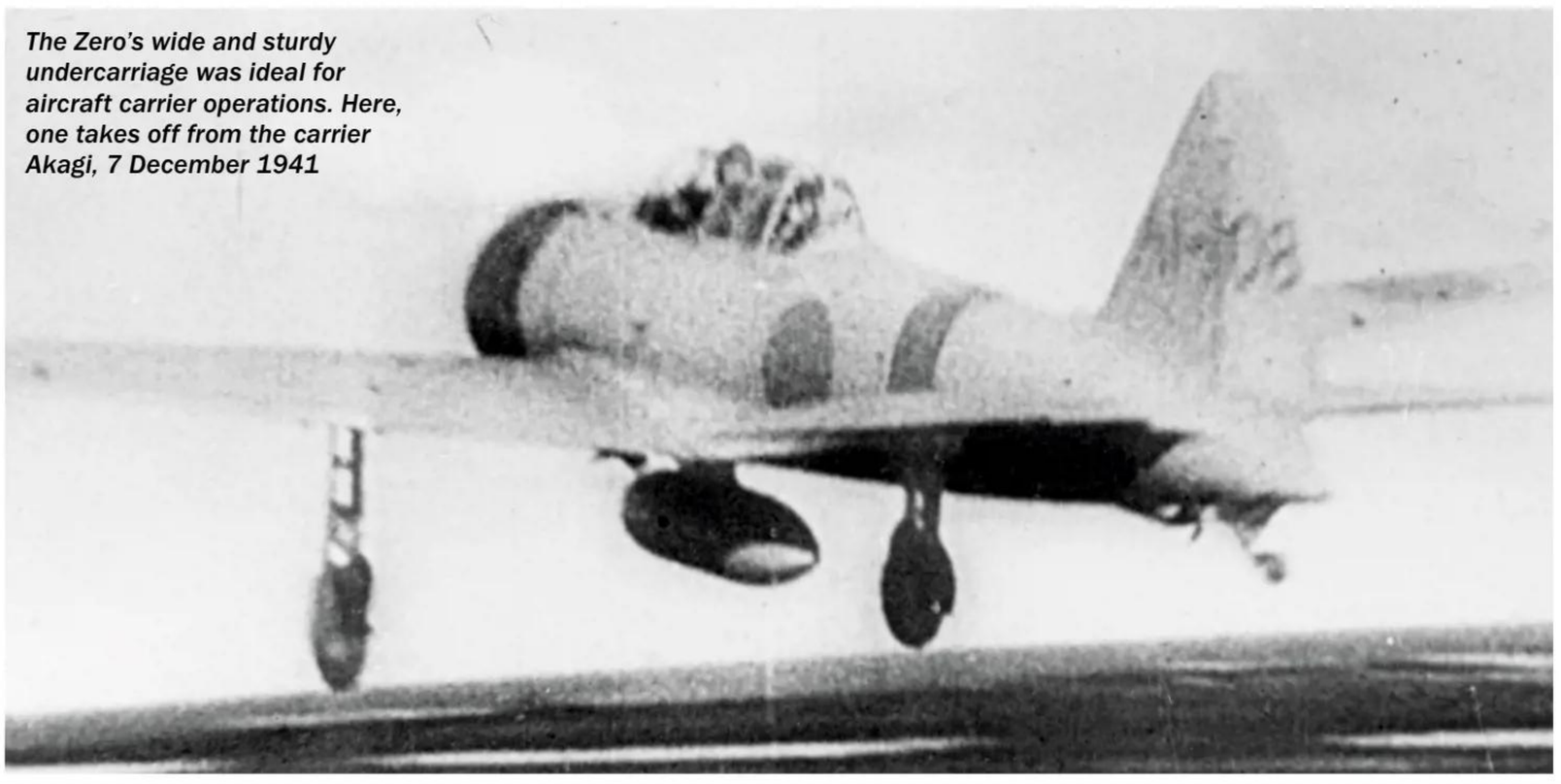
“EVERYTHING WAS DONE TO SAVE WEIGHT, WITH NO ARMOUR OR SELF-SEALING FUEL TANKS, MAKING THE AIRCRAFT LONG-RANGED, FAST, MANOEUVRABLE BUT DESPERATELY VULNERABLE TO ENEMY FIRE”

Clean, elegant lines and a light weight made the Zero a formidable fighter

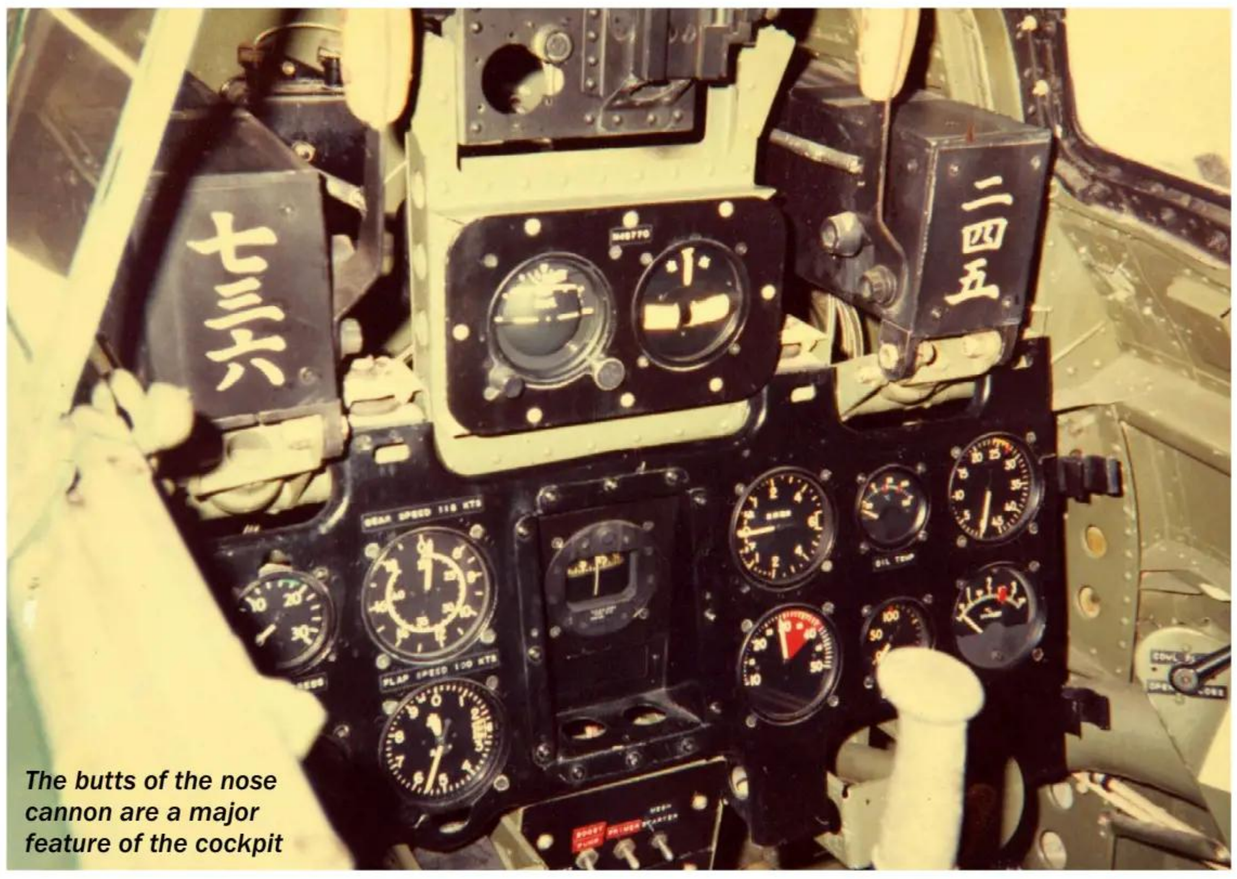
The light construction of the Zero was one of its greatest strengths and greatest weaknesses

DESIGN

A low-wing cantilever design, the Zero was designed for aircraft carrier operations with a short wingspan and wide, sturdy undercarriage. With light construction and a low-wing loading, it was highly manoeuvrable except at high speeds, and had a very low stalling speed. Everything was done to save weight, with no armour or self-sealing fuel tanks, making the aircraft long-ranged, fast, manoeuvrable but desperately vulnerable to enemy fire. Most of the aircraft was built from an aluminium alloy formed to a secret formula called ‘extra super duralumin’.



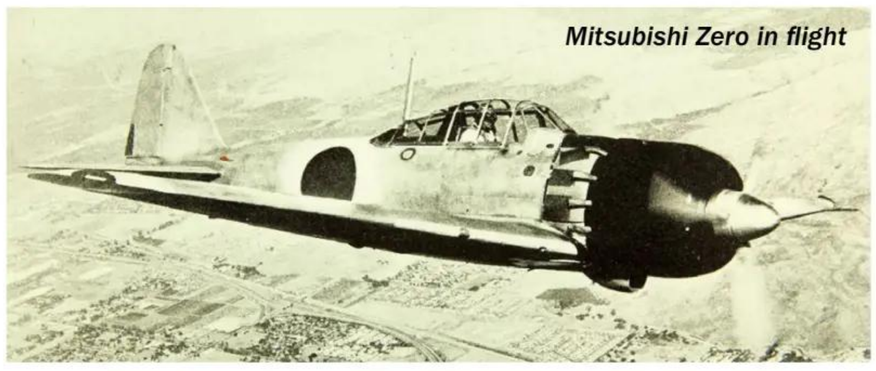
The Zero’s wide and sturdy undercarriage was ideal for aircraft carrier operations. Here, one takes off from the carrier Akagi, 7 December 1941



The butts of the nose cannon are a major feature of the cockpit

COCKPIT

The Mitsubishi A6M had a fully enclosed cockpit that followed the general pattern of most contemporary fighters. A main instrument panel with essential flight indicators in front of the pilot had the gunsight above, flanked on either side by the butts of the machine guns. The panel on the left side of the cockpit contained the throttles and fuel tank selectors. On the right were the radio and its controls, including a direction finding set for navigation at sea, along with the undercarriage and tail-hook switches.



Mitsubishi Zero in flight

Cockpit of the Mitsubishi Zero

SERVICE HISTORY

The Zero entered service in July 1940, and first saw action over China in September. It rapidly proved a formidable fighter in dogfights against Chinese and American (mercenary) units. Fast and highly manoeuvrable, it was also well suited to carrier operations. In late 1941 it was at the spearhead of Japan’s expansion across the Pacific where it easily out-classed all of its initial opponents. However by 1943 the tables were turning with newer Allied aircraft types and tactics exploiting the Zero’s weaknesses, most especially its light construction and inability to take substantial punishment.

By 1944 the type was effectively obsolete, despite several upgrades and minor developments. However a lack of suitable replacements kept it in service and in production. Of the 11,000 built, some 4,000 were built in 1944 and nearly 1,800 in 1945. Pilot quality was also suffering badly, and by October 1944 the type was used for suicide attacks.

An Imperial Japanese Navy Mitsubishi A6M2 Zero on the aircraft carrier Akagi during the Pearl Harbor attack mission

“IN LATE 1941 IT WAS AT THE SPEARHEAD OF JAPAN’S EXPANSION ACROSS THE PACIFIC WHERE IT EASILY OUT-CLASSED ALL OF ITS INITIAL OPPONENTS”

A Japanese Mitsubishi A6M Zero kamikaze plane attacking US Navy ships off the Philippines

The Zero proved terribly vulnerable to the Vought Corsair and other more modern US fighters

All images © Alamy

DE HAVILLAND DH98 MOSQUITO

WORDS & IMAGES **NEILL WATSON**

The Mosquito nearly wasn't built in its incarnation as an unarmed bomber, so the fighter version made production more attractive

Take a look inside Britain's small night bomber nicknamed the 'Wooden Wonder'

The origins of the De Havilland Mosquito can be traced back as far as 1936. Anticipating war, the Air Ministry in the United Kingdom issued a design requirement for a fast, high-altitude bomber capable of spending the minimum amount of time over enemy territory. The design called for a fast aircraft, capable of carrying a 4,000 pound bomb load over 3,000 miles at more than 250 miles per hour.

De Havilland was one of the aviation companies invited to tender, though at the time it was reluctant, as its civilian designs were selling quite well. By 1938, it was becoming apparent that war was almost inevitable in some form, so De Havilland visited the air ministry requirements again. The specification called for an all-aluminium, twin- or four-engine aircraft with fore and aft defensive armament and a high cruising speed.

"THE DESIGN CALLED FOR A FAST AIRCRAFT, CAPABLE OF CARRYING A 4,000 LB BOMB LOAD OVER 3,000 MILES AT MORE THAN 250 MILES PER HOUR"

Speed and agility were the Mosquito's principal defences

"THE SPECIFICATION CALLED FOR AN ALL-ALUMINIUM, TWIN- OR FOUR-ENGINE AIRCRAFT WITH FORE AND AFT DEFENSIVE ARMAMENT AND A HIGH CRUISING SPEED"

Image: Wiki / PD /Gov

Below: *Full scale Mosquito production didn't commence until 1941*

Image: Wiki / PD /Gov

DEHAVILLAND DH98 MOSQUITO

CREW:	2
LENGTH:	44 FT 6 IN (13.57 M)
WINGSPAN:	54 FT 2 IN (16.52 M)
LOADED WEIGHT:	18,100 LB (8,210 KG)
POWERPLANT:	2 × ROLLS-ROYCE MERLIN 76/77 LIQUID-COOLED V12 ENGINE, 1,710 HP (1,280 KW)
MAXIMUM SPEED:	361 KN (415 MPH (668 KM/H) AT 28,000 FT (8,500 M)
RANGE:	1,300 NMI (1,500 MI/2,400 KM) WITH FULL WEAPONS LOAD
ARMAMENT FIGHTER::	4 × HISPANO 20MM CANNON, 4 × BROWNING MACHINE GUNS
ARMAMENT BOMBER:	4,000 LB (1,800 KG)
RATE OF CLIMB:	2,850 FT/MIN (14.5 M/S)
SERVICE CEILING:	37,000 FT (11,000 M)

DESIGN

In the 1930s, the De Havilland Albatross civilian airliner was proving to be a fast and efficient aircraft. A four-engine, all-wood composite monoplane, its clean design and light weight gave it a very fast cruising speed.

De Havilland's proposal, named DH98, was to sacrifice all armament and concentrate on the smoothest, most aerodynamic aircraft possible to simply outrun enemy defences. Drawing on winning experience with the Comet racer in the 1920s, the twin-engine design for the DH98 Mosquito was put forward. The preferred engine was the brand-new Rolls Royce Merlin, but radial-engine Hercules and H-engine Sabre options were also considered.

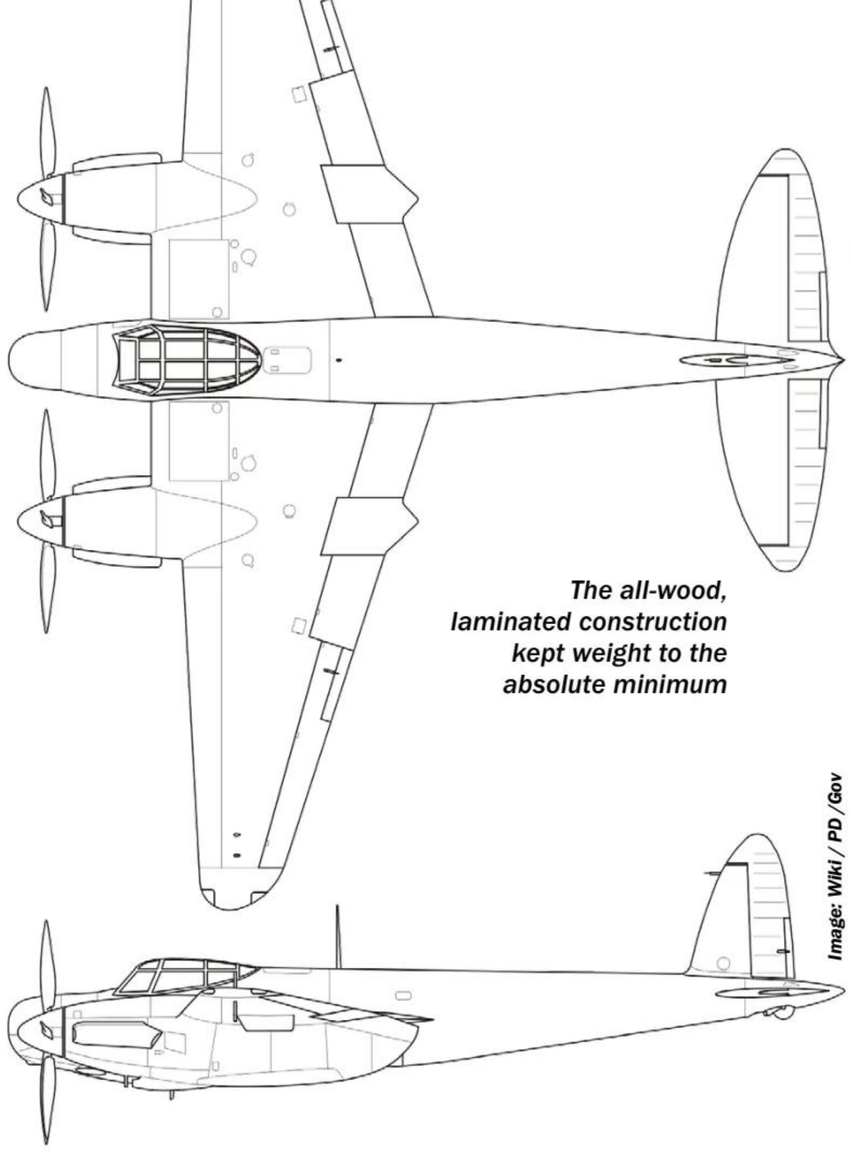
As you may imagine, the lack of any defensive armament was not popular with the Royal Air Force and initial design proposals were rejected out of hand. In July 1938, Geoffrey De Havilland wrote a letter to his contacts at the Air Ministry proposing the argument for all-wood construction and light weight. He stated that in all but torsion, wood matched aluminium and steel in strength and weight. If war were to break out suddenly, metals would become scarce, while wood was in plentiful supply. Additionally, if required, existing carpentry skills of a British workforce could be pressed into service to increase production without specialist metalworking skills.

De Havilland also claimed that the specification would need to be changed and suggested that a sacrifice of either payload or range was needed. He suggested shortening the range to 1,500 miles and proposed a smaller, even lighter twin-engine aircraft with a crew of just two: pilot and navigator.

The design flew in the face of conventional policy at the time, which was one of heavily armed bombers with larger crews manning gun turrets, fighting their way to a target. Resistance by the RAF to an unarmed bomber was strong and though a prototype was commissioned, it was not put into large-scale production. Only when the Air Ministry issued a requirement for a fast twin-engine fighter, which the Mosquito could easily be adapted for, did the project finally gain momentum. By designating the DH98 as a reconnaissance/bomber aircraft, the armament issue was sidestepped for a while.

Having the fighter version of the DH98 probably kept the project alive. By 1940, the aircraft had still not been given full-scale approval, with Geoffrey De Havilland making a bold promise of delivering 50 aircraft in a very short space of time, gambling that once the aircraft was proven, more orders would follow.

Test flying throughout 1941 proved that the aircraft far exceeded the original design requirements. Even in initial tests, the prototype outpaced a Spitfire at 6,000 feet. At high altitude, above 30,000 feet, a maximum speed of 388 miles per hour was achieved, with a calculated service ceiling of 33,900 feet.



The all-wood, laminated construction kept weight to the absolute minimum

Image: Wiki / PD /Gov

***Left:** The cockpit was a tight fit for the crew of two – one sat slightly back from the other for space*

"TEST FLYING THROUGHOUT 1941 PROVED THAT THE AIRCRAFT FAR EXCEEDED THE ORIGINAL DESIGN REQUIREMENTS"

Uprated Merlin engines also became available, which gave the aircraft a top speed of no less than 439 miles per hour, making it the world's fastest operational aircraft at the time.

Demonstrations in front of all Allied air force chiefs proved the performance and agility of the aircraft, demonstrating climbing rolls overhead on only one engine. De Havilland received orders for the aircraft and production commenced in 1941.

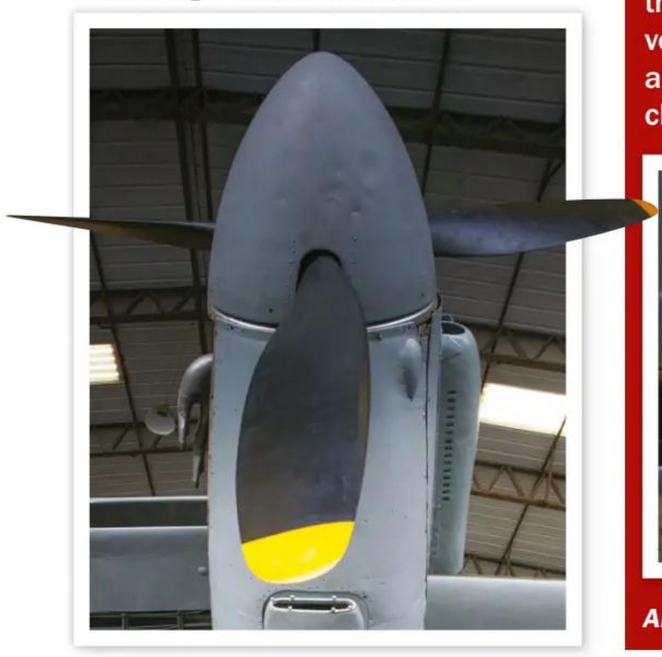
The construction was unique for such a high performance aircraft

“TWO OF THE SUPERCHARGED, 27-LITRE V12 ENGINES WERE FITTED, DRIVING THREE-BLADED CONSTANT SPEED PROPELLERS”

Despite its size, twin supercharged Merlin engines gave the Mosquito more speed than a Spitfire

POWERPLANT

The final engine choice was De Havilland’s first option of the Rolls Royce Merlin. Two of the supercharged, 27-litre V12 engines were fitted, driving three-bladed constant speed propellers. Various versions of the famous Merlin were fitted throughout the aircraft’s production. As newer and more powerful versions were introduced, they were made available to the Mosquito production and ensured its superior performance advantage was maintained.



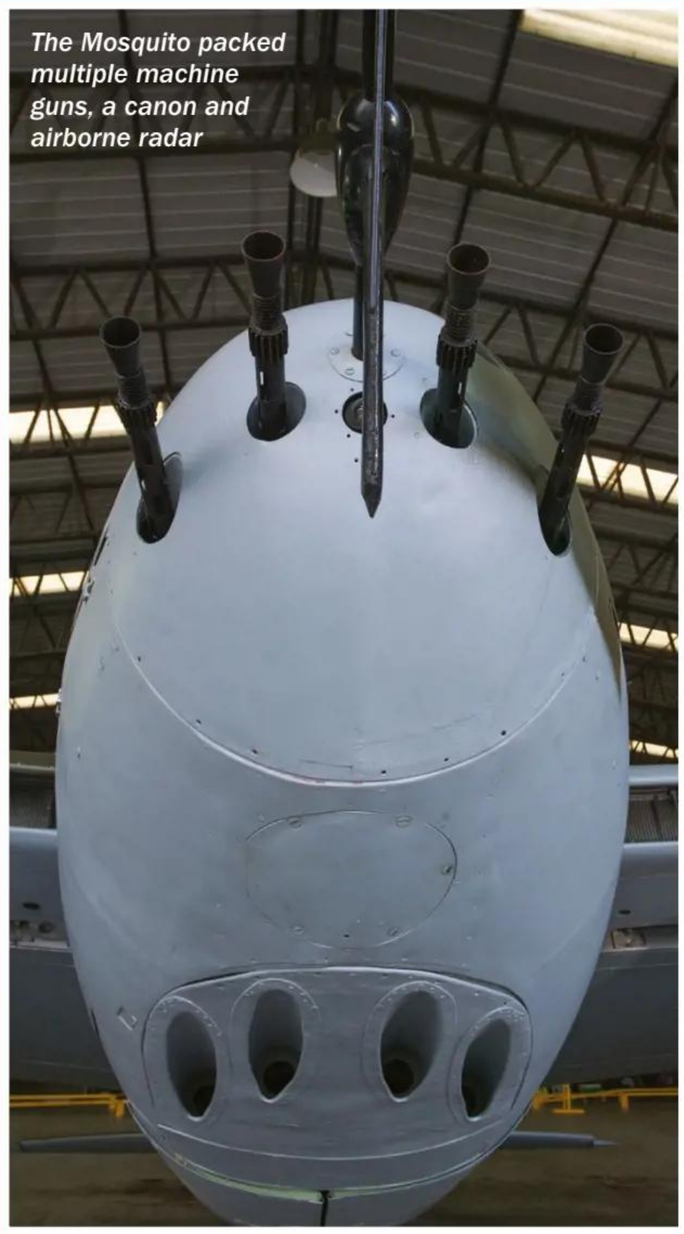
ARMAMENT

Though initially designed as an unarmed bomber, the long-range fighter variant proved to be highly effective. Four Browning machine guns were mounted in the nose, supplemented by four Hispano 20mm cannon in the fuselage belly. As a night fighter, it had early-generation airborne radar fitted. The combination of radar, weaponry, speed and range enabled the fighter version to attack far-off German airfields, while also defending the skies at night over the UK.

The bomber variant and photo reconnaissance versions were unarmed. Crews grew to love the high-altitude performance and agility as they gained confidence in being able to outrun and outmanoeuvre the opposition.

The fully enclosed bay carried 4,000 pounds of bombs, either as a cluster of smaller bombs, or later as a single, thin-cased 4,000 pound ‘cookie’ bomb. Photo reconnaissance versions carried a selection of cameras and were often used ahead of both day and night bomber missions over Europe to check weather conditions.

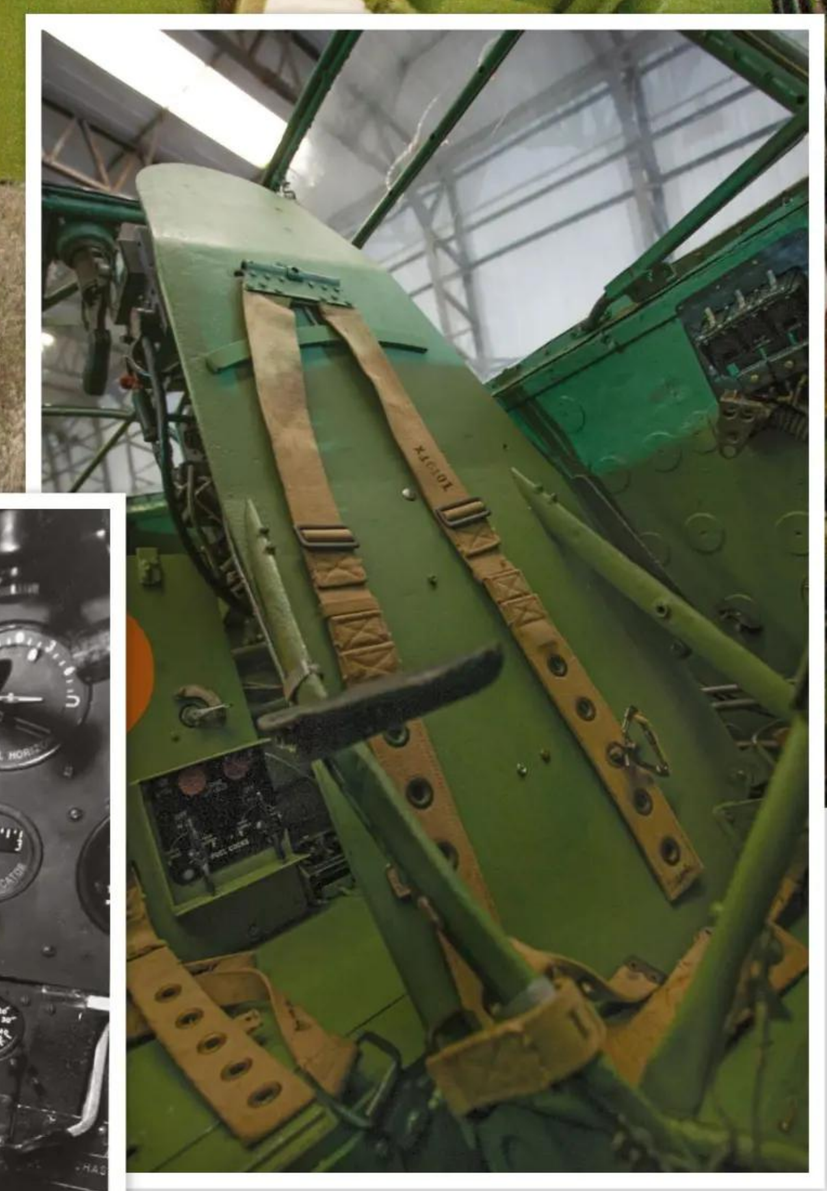
Above: *The Mosquito bomb bay carried a variety of explosives*



The Mosquito packed multiple machine guns, a canon and airborne radar

“FIGHTER VERSIONS HAD A SOLID NOSE, WHILE BOMBER VARIANTS FEATURED A GLASS NOSE TO ALLOW THE CREWMAN TO USE THE NORDEN BOMB SIGHT”

The crew of two had very little room inside the cramped cockpit



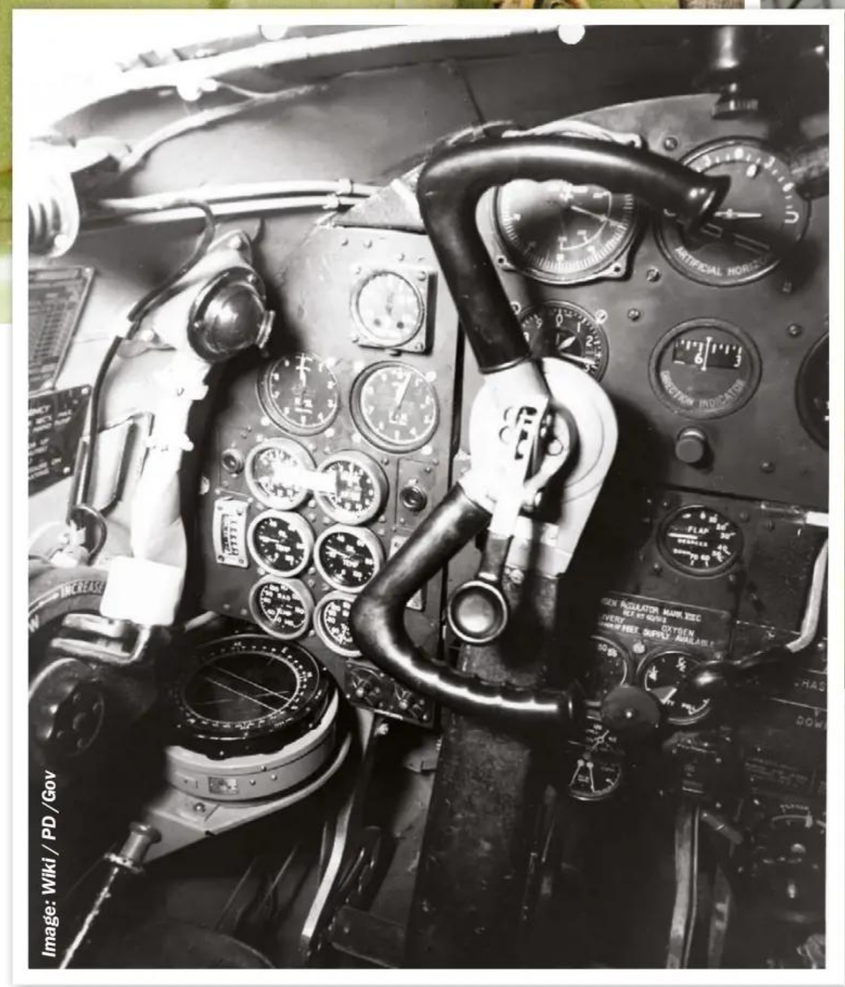
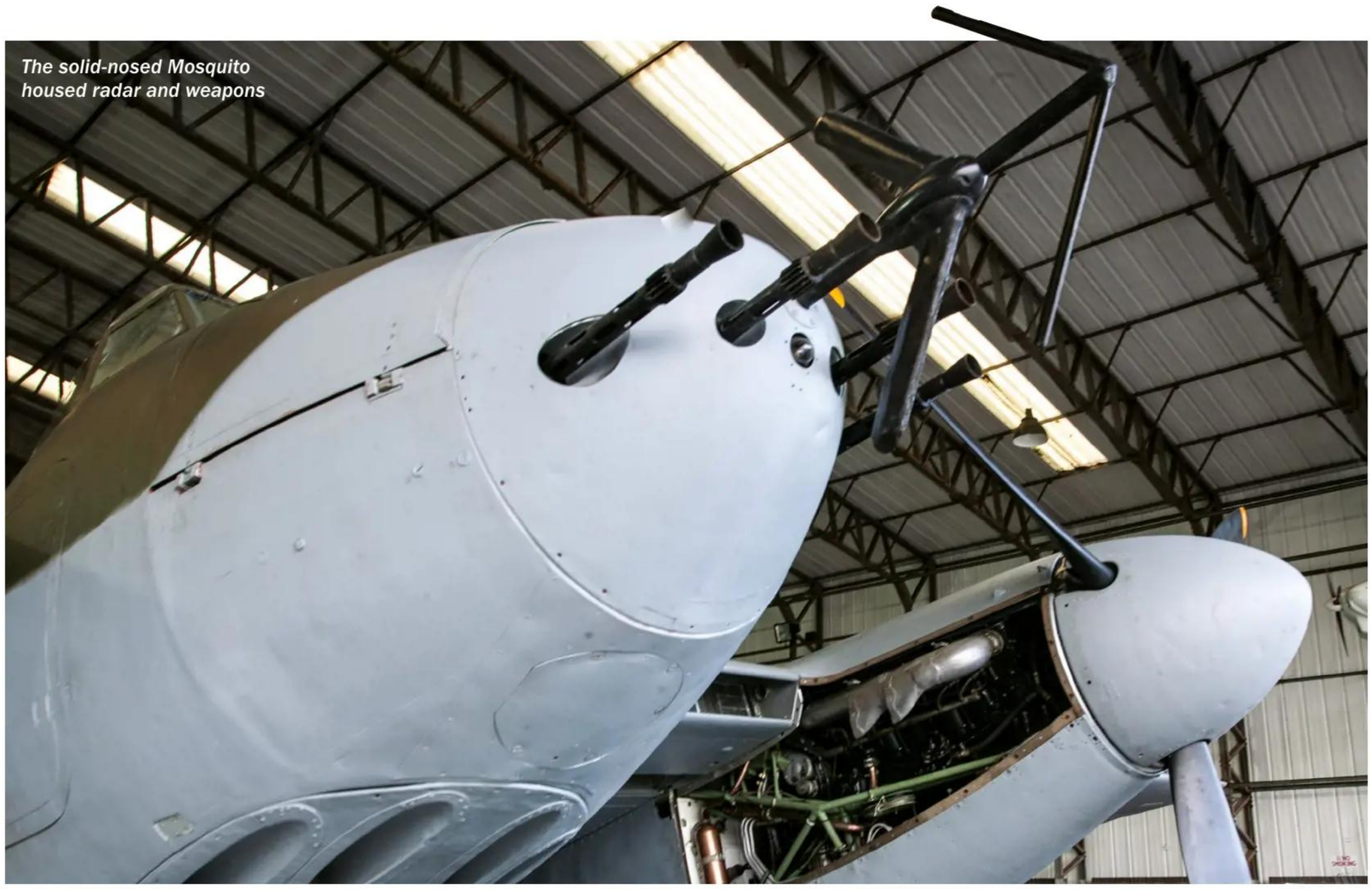


Image: Wiki / PD /Gov

***Above:** The pilot’s seat featured an armour-plated headrest*
***Left:** Different models had either control column or fighter control stick*

COCKPIT

The machine carried a crew of two in quite a small area, with the pilot sat on the left and the second crew member on the right and slightly behind, giving more shoulder and elbow room. The second crewman would undertake a variety of duties, including navigation, bomb aiming and operation of the night fighter radar. Fighter versions had a solid nose, while bomber variants featured a glass nose to allow the crewman to use the Norden bomb sight and deliver the bomb load on target.



The solid-nosed Mosquito housed radar and weapons

***Below:** Mosquitos were vital for gaining intelligence on photo reconnaissance missions*

IN SERVICE

Mosquitos became famous for several daring, high-profile raids over enemy territory including the raid on the Gestapo headquarters in Oslo, Norway, requiring flight across the North Sea at less than 100 feet. The raid was subsequently dramatised into the post-war film *633 Squadron*.

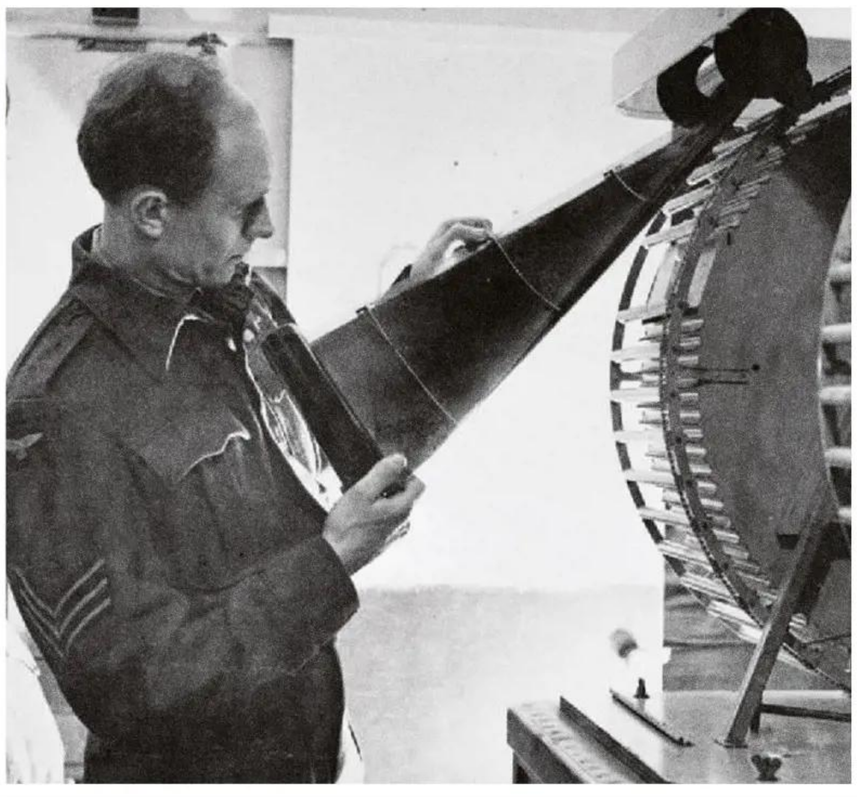
In 1944, Mosquitos were engaged in Operation Jericho, a very low-level raid with the objective of breaching the walls of Amiens prison, freeing French resistance fighters and other German-held prisoners who were all due to be executed. The raid became controversial after the war but as a demonstration of low-level precision bombing, it was a propaganda coup at the time.

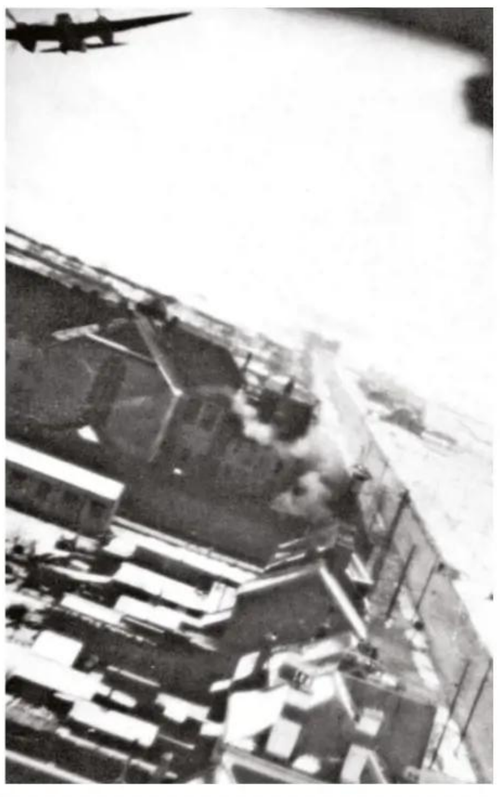
The most famous role of Mosquitos was as Pathfinder bombers, flying ahead of the main bomber force and marking the target with flares and incendiary bombs. The crews often had to remain over the target to monitor the success of the main force, sometimes repeatedly marking the target while under fire to ensure the bomber force was accurate.

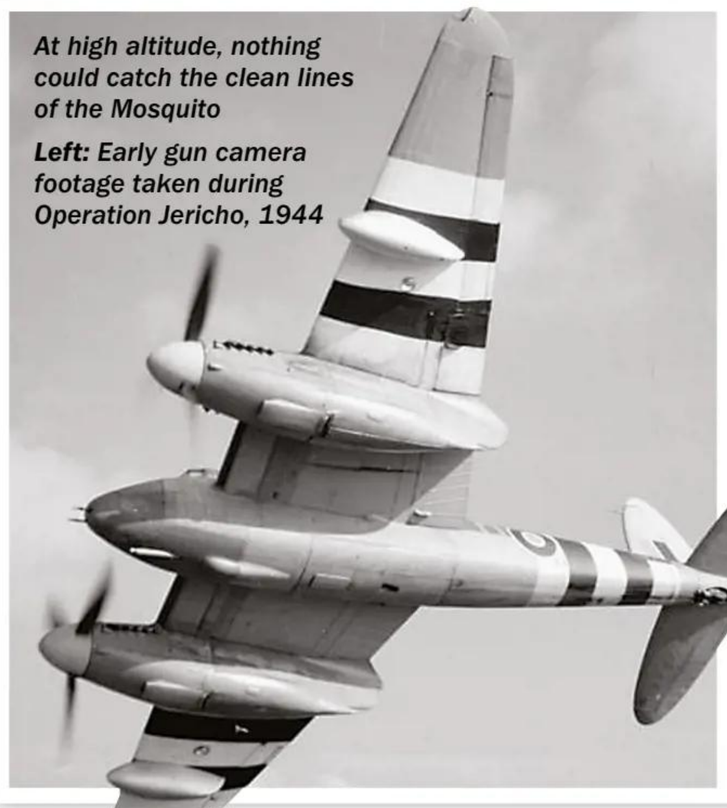
As a night fighter, the Mosquito carried early-generation airborne radar to intercept German bombers. Radar technology was pioneered in World War II and as equipment became more portable, it could be fitted into aircraft like the Mosquito. Several British pilots became night fighter aces, including Group Captain John Cunningham, named 'Cat's Eyes Cunningham' by the British press in an attempt to disguise the airborne technology. As the war progressed, Mosquitos flew night fighter offensive missions over Germany, actively seeking out their German counterparts in the darkness.

Mosquitos were also used during the war to obtain ball bearings from neutral Sweden. These aircraft were given civilian registration marks and ostensibly flown by British Overseas Airways Corporation, with pilots wearing civilian clothing. Ball bearings were vital for the war effort and the Mosquito bomb bays were loaded in Stockholm and flown to Scotland, BOAC becoming known as the Ball Bearing Airline. They also regularly carried British newspapers and magazines outbound, plus espionage experts or escaped airmen back to the UK who had escaped across the borders into neutral Sweden.

The performance advantage of the Mosquito remained throughout its service life, only being replaced by the advent of the jet age aircraft in the years after World War II. Today just a handful of aircraft remain, with two airworthy.







At high altitude, nothing could catch the clean lines of the Mosquito

***Left:** Early gun camera footage taken during Operation Jericho, 1944*

Images: Wiki / PD /Gov

MESSERSCHMITT

Take a tour around one of World War II's most iconic aircraft and the backbone of the Third Reich's Luftwaffe

WORDS **NEILL WATSON**

The aircraft seen here is an accurate replica of a 1943 Bf 109G-6, with the unique pattern used by Hermann Graf of JG.50 – he ended the war with 212 confirmed victories in the air

MESSERSCHMITT BF 109G

CREW:	1
LENGTH:	8.95M (29FT 7IN)
WINGSPAN:	9.925M (32FT 6IN)
HEIGHT:	2.6M (8FT 2IN)
WING AREA:	16.05M² (173.3FT²)
EMPTY WEIGHT:	2,247KG (5,893LB)
LOADED WEIGHT:	3,148KG (6,940LB)
MAX TAKEOFF WEIGHT:	3,400KG (7,495LB)
POWERPLANT:	1 X DAIMLER-BENZ DB 605A-1 LIQUID-COOLED INVERTED V12, 1,455HP (1,085KW)
PROPELLERS:	VDM 9-12087 THREE-BLADED LIGHT-ALLOY PROPELLER
PROPELLER DIAMETER:	3M (9FT 10IN)

BF 109G

Image: Wiki / Bundesarchiv, Bild 101I-649-5382-31A / Lechleitner / CC-BY-SA 3.0

Right: *Though designed as a short range interceptor, Bf 109 variants served in many roles across all fronts*

"WHILE ULTIMATELY NOT THE VERY BEST FIGHTING PLATFORM BY 1945, IT WAS BUILT IN HUGE NUMBERS, WITH MORE THAN 33,000 CONSTRUCTED BETWEEN 1937 AND 1945"

Fighting against its arch rival the Supermarine Spitfire, the Messerschmitt Bf 109 is probably the most famous Axis fighter of World War II. In the early years of the war, it was the main single-engine fighter interceptor of the Luftwaffe. While the E variant began to be outclassed by the Spitfire Mk IX after the Battle of Britain and was eventually replaced by the Focke Wulf 190, the Bf 109 in fact continued to serve across all fronts of German combat right until the war's end. While ultimately not the very best fighting platform by 1945, it was built in huge numbers, with more than 33,000 constructed between 1937 and 1945. The most numerous variant was the Bf 109G, with more than one-third of all aircraft being this specification.

Originally designed as a short-range, high-speed, extremely agile interceptor, the Bf 109 was built in response to a tender by the German Reich Aviation Ministry in 1933. It was one of several specifications laid out by the Reich at the time that formed the future of the Luftwaffe as Germany prepared for war. Heinkel, Arado, BFW and Focke Wulf all competed for the contract. The specification was for a fighter with a top speed of more than 400 kilometres per hour at 20,000 feet but with a flight endurance of only 90 minutes. The German Blitzkrieg warfare tactics at the time anticipated that close air support behind the main advancing front would be the main area of operations.

The Bf 109 made its debut in 1935 and played an active part in the Spanish Civil War, something that gave Luftwaffe pilots a crucial initial edge of combat experience at the outset of World War II.

DESIGN

The Bf 109 initially had a 700-horsepower Jumo V12, but when the prototypes were ready, the engines were behind schedule. The Bf 109 at first flew with a Rolls-Royce Kestrel engine, acquired by trading a Heinkel aircraft with Rolls-Royce, who needed an engine test bed.

Other advanced technologies included leading edge slats that deployed automatically to enhance combat manoeuvring. Early test pilots were wary of the design, with on-the-limit handling in steep combat turns becoming tricky. However, once mastered, the agility gave it an edge in air-to-air combat. Other elements that pilots disliked were the undercarriage arrangement and the fact that the canopy was designed to open sideways rather then slide back, meaning that it could not be opened in flight.

However, there is little doubt that the Messerschmitt was designed to survive combat. The engine was inverted, making it more difficult to damage by ground fire, while also giving the aircraft the ability to undertake negative-G manoeuvres in ways that Merlin-engined aircraft could not follow. The radiators had two separate systems that could be shut off independently in the event of damage, which allowed the pilot to continue flying. The aircraft would even continue to fly for five minutes with no radiators, giving the pilot a chance to escape from a dogfight if damaged.

Additionally, the fuselage fuel tank was behind the pilot and also behind the armour plating, reducing the possibility of penetration by gunfire and also burns to the pilot.

The initial Jumo engines were underpowered, with the Daimler-Benz engine eventually replacing it in a major redesign of the E series. The Bf 109E 'Emil' had major structural changes to accommodate the 1,100-horsepower Daimler-Benz engine. This model formed the basis for the G 'Gustav' series from 1942 onwards.

The design by Willy Messerschmitt used cutting-edge technologies at the time to create an extremely light monoplane design. Wherever possible, the number of components was minimised, with load-bearing structures such as engine and wing mounts being combined into one assembly. The unusual aircraft landing gear was also mounted on the same structure, which gave rise to the rather odd looking stance when on the ground. While it made the aircraft difficult to handle in landing and takeoff, it did allow the wings to be quickly removed with the gear in place, making for rapid battle damage repairs. The engine was a liquid-cooled V12, running inverted with the exhaust stacks at the bottom of the cowlings.

The unusual undercarriage layout made the Messerschmitt tricky to handle on the ground

"THE DESIGN BY WILLY MESSERSCHMITT USED CUTTING-EDGE TECHNOLOGIES AT THE TIME TO CREATE AN EXTREMELY LIGHT MONOPLANE DESIGN"

This 100% accurate replica of the Bf 109G can be seen on display at the Yorkshire Air Museum

Additional cannon were added as a field modification to improve armament

Images: Wiki / Bundesarchiv, Bild 101I-662-6659-37 / Hebenstreit / CC-BY-SA 3.0

POWERPLANT

The Bf 109G was powered by the Daimler-Benz DB605 liquid-cooled V12 engine. This developed 1,475 brake horsepower and was the engine that would power the Messerschmitt variants for the rest of the war. The engine was a V12, inverted, liquid-cooled engine developed as a high-performance version of the earlier DB601. To keep pace with Rolls-Royce Merlin advances, it was designed to rev higher and run with greater supercharger boost than previously, while still remaining reliable in combat and not overheating. The supercharger clutch was automatic, as was the electric pitch control for the propeller, giving the pilot less to worry about in the stress of combat situations.

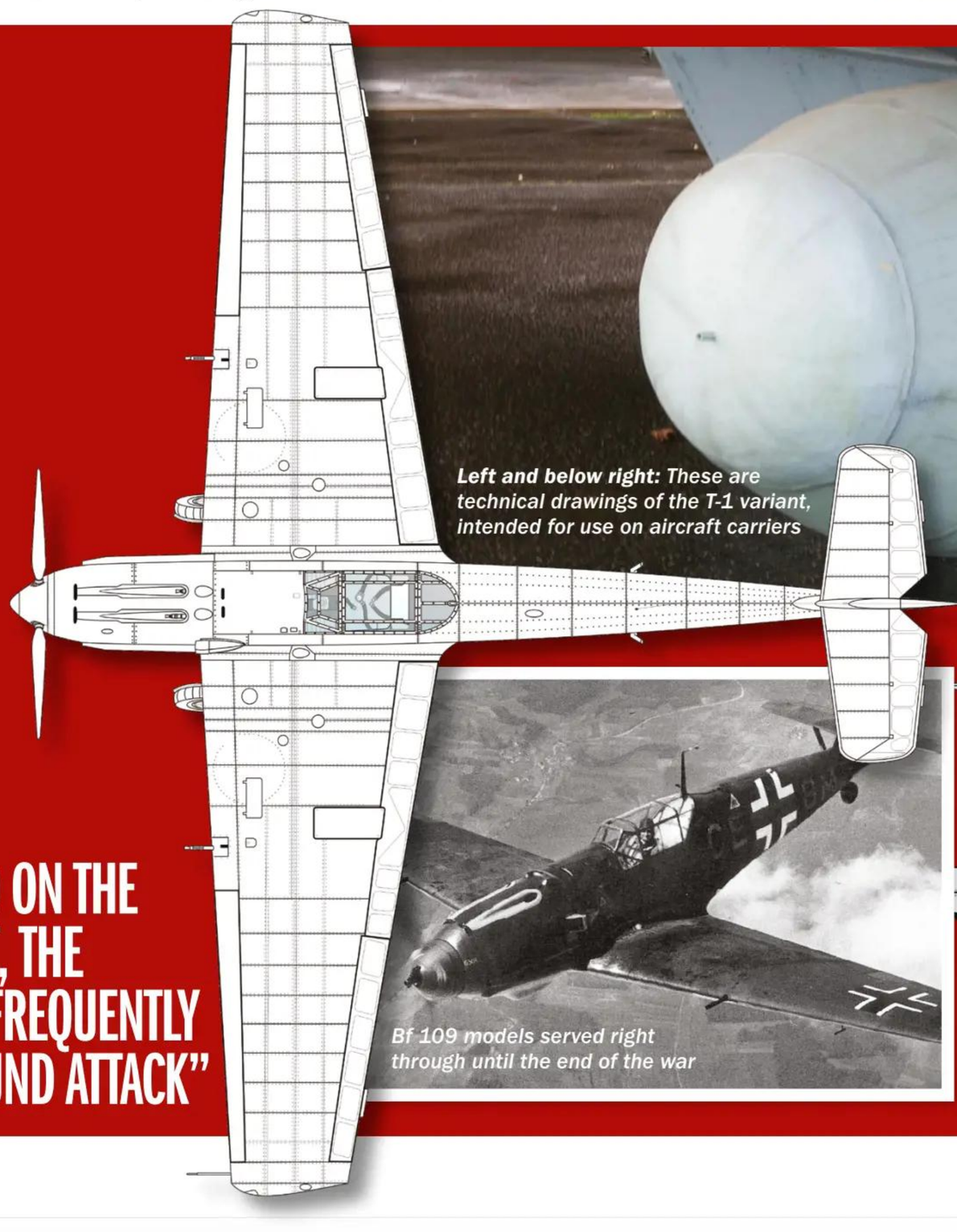
Aviation fuel is typically 100 octane, but Daimler-Benz designed the engines to run at reduced power on lower octane fuels, even as low as 87 octane. This meant that in frontline combat where aviation fuel may be scarce, the aircraft could continue fighting using whatever fuel could be found.

The Daimler Benz liquid cooled inverted V12 was particularly robust and able to continue operating when damaged

ROLES AND DIVERSITY

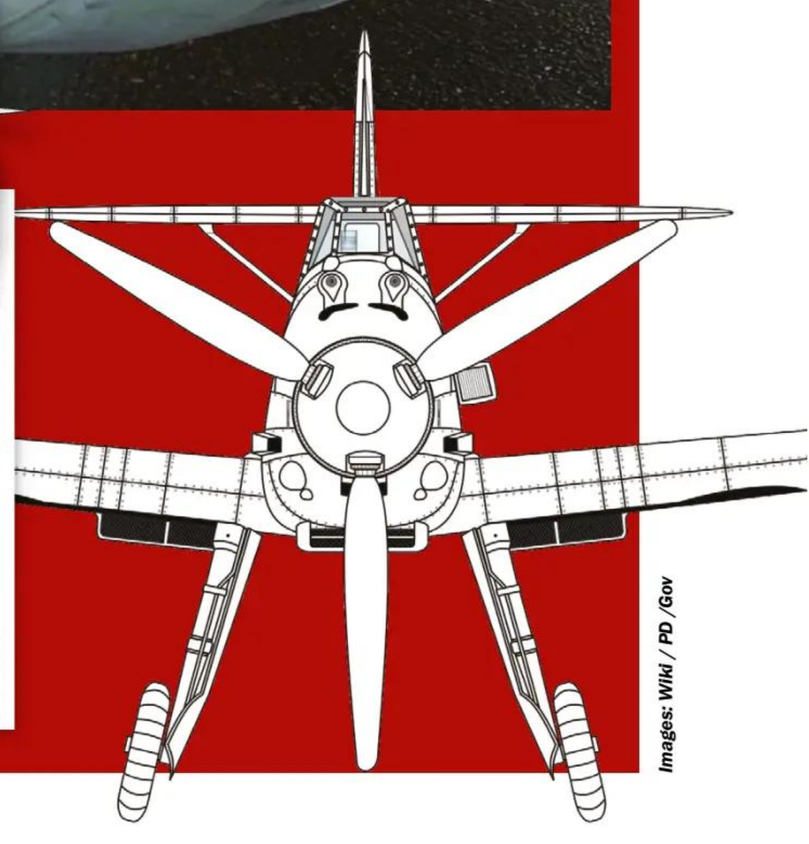
Though originally designed solely as a short-range high-performance interceptor, the Bf 109G was pressed into service in other areas. In Africa and on the Soviet front, the aircraft was frequently used for ground attack, able to carry a single bomb centrally in addition to the cannon and machine guns carried onboard. As with the Allied Supermarine Spitfire, the Bf 109 was adapted for different roles and

"IN AFRICA AND ON THE RUSSIAN FRONT, THE AIRCRAFT WAS FREQUENTLY USED FOR GROUND ATTACK"



***Left and below right:** These are technical drawings of the T-1 variant, intended for use on aircraft carriers*

Bf 109 models served right through until the end of the war



Images: Wiki / PD /Gov

The Bf109G had a central cannon firing through the propellor spinner

COCKPIT

The pilot sat in a seat designed to be used with a parachute. Armour plating behind him also covered the rear fuel tank for additional protection. Ahead was a bulletproof windscreen. The central-mounted cannon was also visible in the cockpit, which must have been deafening when in use. Pilots often criticised the cockpit canopy, both for the shallow frame that obscured vision and the fact that it hinged open sideways, meaning that it could not be opened in flight. In keeping with the compact design philosophy of Willy Messerschmitt, the cockpit was a tight fit.

***Left:** With a side-opening canopy, the cockpit was far harder to bail out of while in flight – an understandably unpopular feature with pilots*

ARMAMENT

The thin, high-performance wing of the Messerschmitt Bf 109G meant that most of the armament was positioned centrally. Twin machine guns in the fuselage were supplemented by a 20mm cannon mounted in the centre of the V12 engine. This fired through the centre of the propeller spinner.

As the war progressed, this firepower was becoming ineffective, so the Luftwaffe introduced field modifications known as Rüstsätze. This was typically a kit capable of being retrofitted in the field by ground crew. Such kits were generally mounted under the wing and included payloads such as extra cannon for ground attack, machine-gun pods or drop tanks to increase the limited range. This gave the aircraft additional diversity to enable the fight to continue, in particular on the Russian Front and in Africa.

WEAPONS

GUNS:	2 X 13MM (0.51IN) SYNCHRONISED MG 131 MACHINE GUNS WITH 300 ROUNDS PER GUN 1 X 20MM (0.78IN) MG 151/20 CANNON WITH 200 ROUNDS PER GUN, OR 1 X 30MM (1.18IN) MK 108 CANNON WITH 65 ROUNDS PER GUN (G-6/U4 VARIANT), 2 X 20MM MG 151/20 UNDER-WING CANNON PODS WITH 135 ROUNDS PER GUN (OPTIONAL KIT: RÜSTSÄTZE VI)
ROCKETS:	2 X 21CM (8IN) WFR GR 21 ROCKETS (G-6 WITH BR21)
BOMBS:	1 X 250 KG (551LB) BOMB OR 4 X 50KG (110LB) BOMBS OR 1 X 300-LITRE DROP TANK

Top German fighter aces amassed hundreds of kills and sometimes had aircraft painted with their own colours

POST-WAR

Almost 34,000 Messerschmitt Bf 109s were built from 1935 until 1945, yet only about 100 survive today. Many are static, though some are still in flying condition. Most of those that survive were either captured by the Allies at the end of the war or recovered from combat areas of Russia and Eastern Europe, where they were abandoned and lost in large numbers at the end of the conflict.

A British soldier poses on top of a downed Bf 109 E, during the Battle of Britain

Image: Wiki / PD /Gov

NORTH AMERICAN P-51 MUSTANG

Despite an unpromising start, the Mustang became a world-class fighter and the aircraft that destroyed the Luftwaffe

WORDS **STUART HADAWAY**

The North American P-51D is widely considered to be the definitive version of the Mustang

The P-51 Mustang is one of the greatest fighter aircraft of all time and played a definitive role in winning the air battle over Europe during World War II.

The initial models with Allison engines had poor high-level performance but excellent lower-level characteristics. When it first entered service with the RAF in January 1942, the Mustang was used mainly for photo-reconnaissance sorties, which rapidly evolved to include ground-attack sweeps.

Meanwhile, the USAAF became interested in the P-51. As the USAAF doctrine of self-defending bombers was proven unsound, it looked for a long-range escort fighter. The Allison-engined P-51A would not do, but the new P-51B,with a Merlin engine and drop-tanks fitted the bill perfectly, and large numbers were ordered. These arrived with the Eighth Air Force in the UK in December 1943. In January 1944 Mustangs made their first sortie over Germany, and in March operated for the first time over Berlin. The improved P-51D became the Eighth Air Force's primary fighter in 1944. From close bomber escort work they expanded into 'sweeps' across Germany and occupied Europe, systematically destroying the Luftwaffe in the air and on the ground. The P-51 would destroy more German aircraft than any other Allied fighter, and over 250 USAAF pilots scored five or more victories while flying the Mustang.

The P-51 played a lesser role in the Far East, although it was used by the Chinese Nationalists, and in 1945 flew escort operations for USAAF B-29 Superfortresses over Japan.

“THE P-51 WOULD CLAIM MORE GERMAN AIRCRAFT DESTROYED THAN ANY OTHER ALLIED FIGHTER”

NORTH AMERICAN P-51D MUSTANG

COMMISSIONED:	1940
ORIGIN:	USA/UK
LENGTH:	9.83M (32FT 3IN)
RANGE:	1,530KM (950 MI) ON INTERNAL TANKS
ENGINE:	1,490-HORSEPOWER, LIQUID-COOLED, V-12 PACKARD MERLIN
CREW:	1
PRIMARY WEAPON:	6 X BROWNING .50-CALIBRE MACHINE GUNS
SECONDARY WEAPON:	2 X 454KG (1,000LB) BOMBS OR 10 X 127MM (5IN) ROCKETS

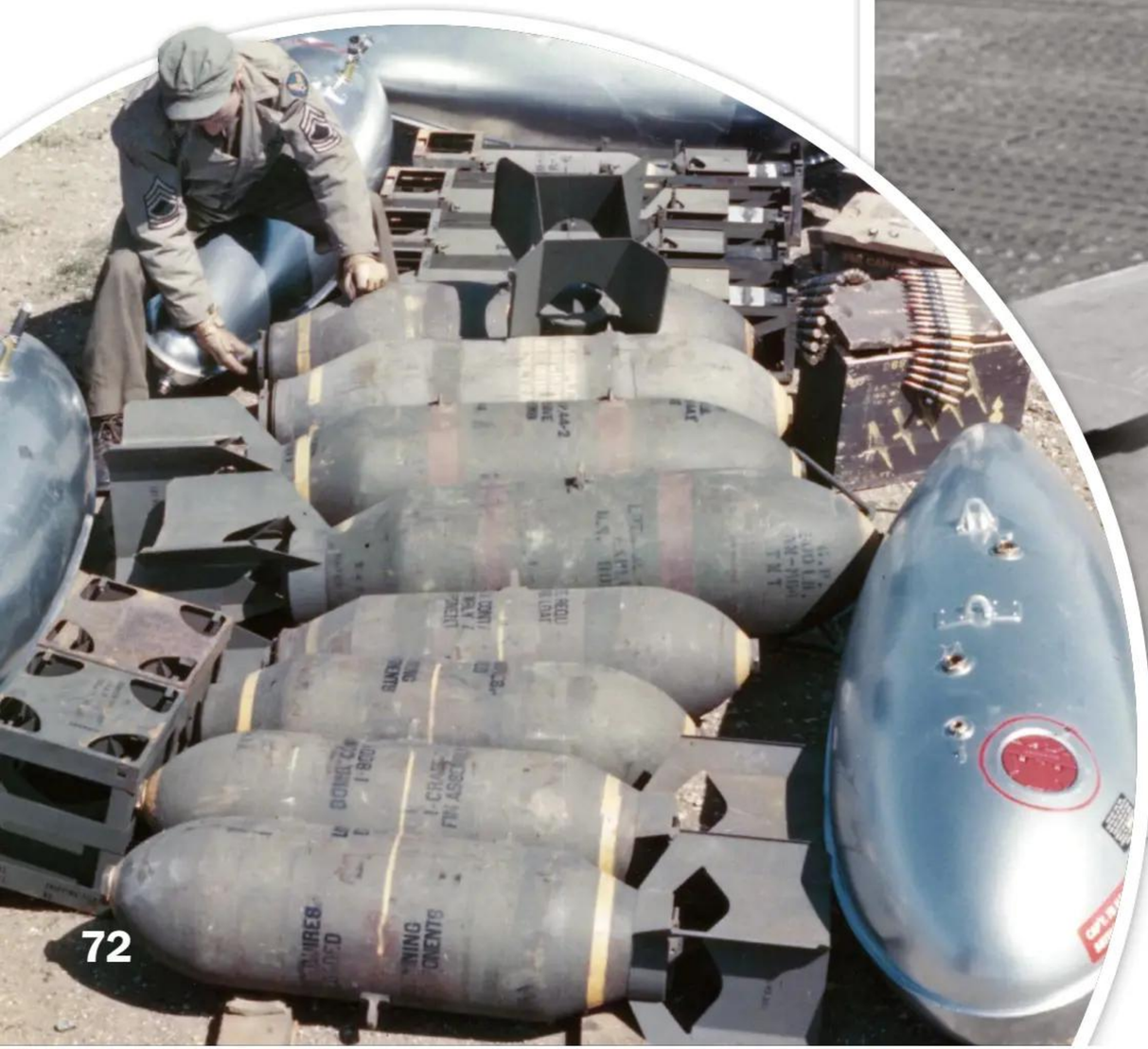
Illustration: Alex Pang

“WHEN THE USAAF ADOPTED THE AIRCRAFT THE NOSE GUNS DISAPPEARED (AS THEY QUICKLY DID IN RAF SERVICE) AND ARMAMENT CHANGED TO FOUR 20MM HISPANO CANNON IN THE WINGS”

Armourers prepare to load a Mustang’s six .50-calibre machine guns. 36 such belts of ammunition would be needed

ARMAMENT

Early RAF models had four Browning M1919 .30-calibre and two Browning M2 .50-calibre machine guns in the wings, and another two .50-calibre machine guns in the nose. When the USAAF adopted the aircraft the nose guns disappeared (as they quickly did in RAF service) and armament changed to four 20mm Hispano cannon in the wings. Various other changes occurred in new models, but the P-51D/Mustang IV had six M2 Browning .50-calibre machine guns, and bomb racks under each wing capable of carrying 1,000-pound bombs. Up to ten 127 mm (five-inch) rockets could also be carried.



***Left:** P-51 bombs flanked by the all-important fuel drop-tanks, which gave the Mustang the range to fight over Germany*

"THE CLASSIC TEARDROP CANOPY (INSPIRED BY THE HAWKER TYPHOON) WAS ADDED, GIVING AN EXCELLENT ALL-ROUND VIEW AND IMPROVED AERODYNAMICS"

Three P-51Ds and a P-51B of the 375th Fighter Squadron, 361st Fighter Group, over France, July 1944

***Below:** Rockets stacked on an airfield, ready for use*

***Below:** A P-51 drops napalm over a North Korean town during the Korean War*

An armourer of the 332nd Fighter Group. Known as the 'Tuskegee Airmen'. The 332nd's air and ground crew were all African-American, and had to fight deep institutional racism

DESIGN

The P-51 was designed to RAF specifications. After the concept design was approved and an order placed on 29 May 1940, the prototype rolled out just over 100 days later (though the engine took another month). The Mustang was lightweight aluminium, with an aerodynamically placed ventral radiator and efficient, laminar wings. Early versions had blocky, three-panel hinged cockpits, later changed by the RAF (and on some USAAF aircraft) to Spitfire-style bulbous 'Malcolm Hoods'. When the P-51D/Mustang IV was being designed, the classic tear-drop canopy (inspired by the Hawker Typhoon) was added, giving an excellent all-round view and improved aerodynamics.

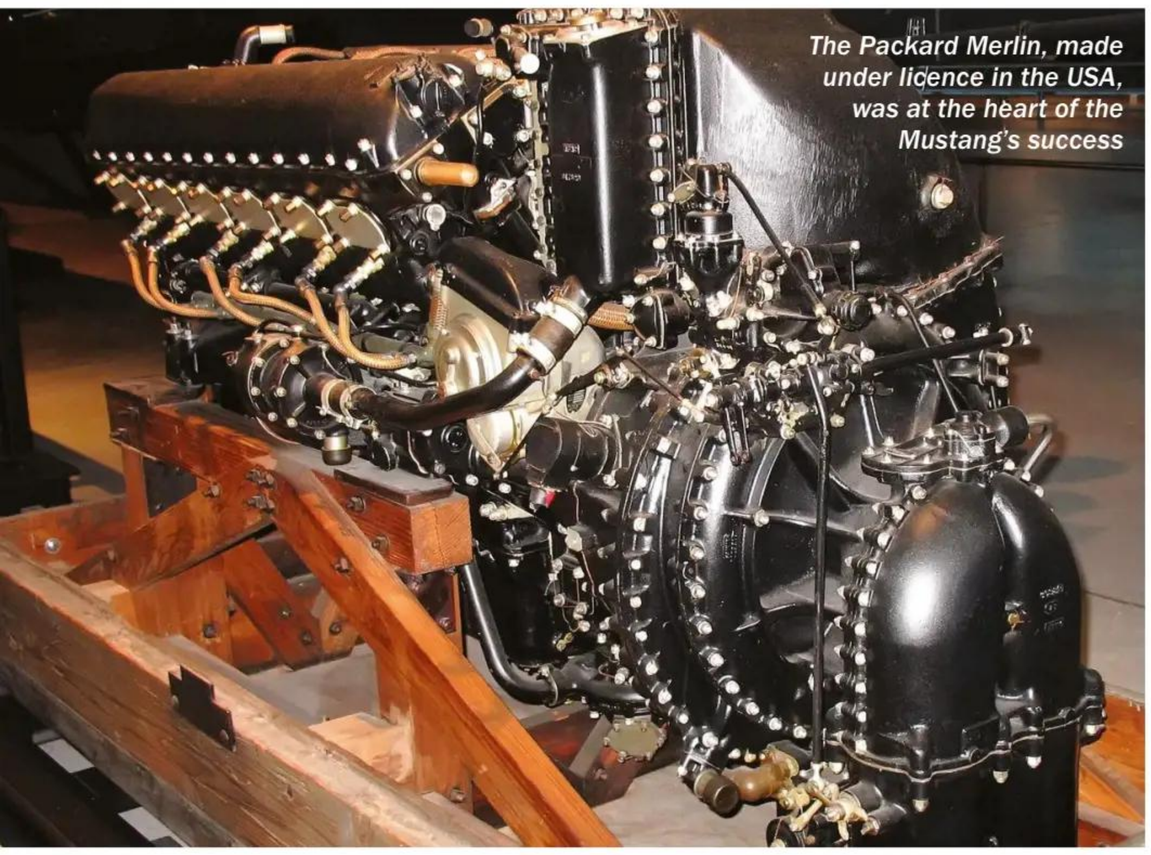
One of the many P-51s still flying around the world today

Images: Alamy, Getty

ENGINE

The engine was the key to the Mustang's success. It was originally fitted with the 1,150-horsepower Allison V-1710-39 liquid-cooled V12, which provided great low-level performance but was poor above 15,000 feet. Then, in mid-1942 Rolls Royce test pilot Ronald Harker asked to put a Merlin engine in a Mustang. After a long struggle he was allowed, and a truly superb fighter was born. Equipped with the US-made 1,300-horsepower Packard Merlin V-1650-3 liquid-cooled V12, with two-stage supercharger, the Mustang had excellent performance at all levels and could escort heavy bomber raids and confront the Luftwaffe head-on.

The smooth aluminium finish on the Mustang increased its speed by several kilometres per hour, while the black section across the top of the nose stopped reflections from dazzling the pilot



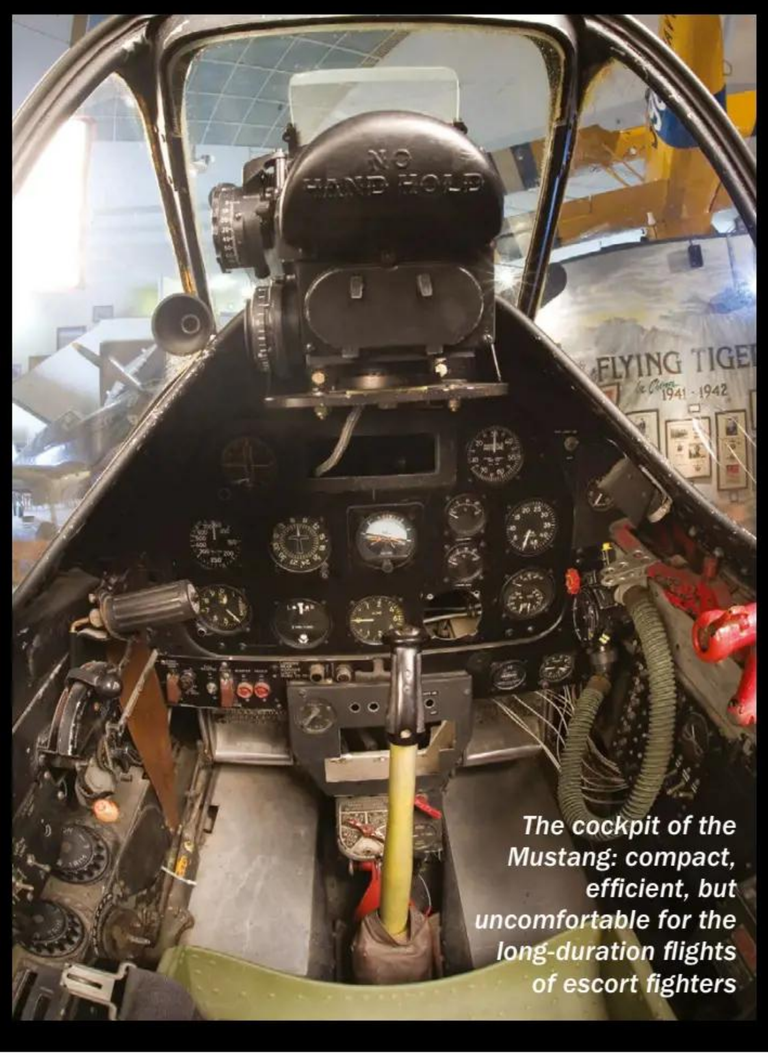
The Packard Merlin, made under licence in the USA, was at the heart of the Mustang's success

COCKPIT

Small like all fighter cockpits, Mustangs had the standard flight instruments in front of the pilot. On the left side of the cockpit were the throttle, propeller and mixture controls, drop-tank switches, trim controls and undercarriage lever. On the right side were the electronics switches and dials underneath the VHF radio and Indicator Friend or Foe controls. Crucial to high-altitude operations over Europe, at the front right corner of the pilot's seat was the hot air vent (twist clockwise for more heat) and at the front left corner the defroster control to clear the windscreen.

"CRUCIAL TO HIGH-ALTITUDE OPERATIONS OVER EUROPE, AT THE FRONT RIGHT CORNER OF THE PILOT'S SEAT WAS THE HOT AIR VENT"

The high nose of the Mustang gave the pilot a poor view on the ground. Pilots would weave so they could see ahead around it



The cockpit of the Mustang: compact, efficient, but uncomfortable for the long-duration flights of escort fighters

SERVICE HISTORY

LEGEND HAS IT THAT LUFTWAFFE CHIEF HERMANN GÖRING SAID, "THE DAY I SAW MUSTANGS OVER BERLIN, I KNEW THE JIG WAS UP"

The P-51A (US designation)/Mustang I (RAF designation) entered service with the RAF in January 1942. Its excellent low-level performance made it ideal for photo-reconnaissance and ground attack work over occupied Europe, although the RAF occasionally used them as fighters.

It was the P-51B/Mustang III that became the first true fighter version, when the Allison engines were replaced by Merlins. Other improvements were also made, and this type entered front-line service with the USAAF Eighth Air Force in the UK in December 1943. A few months later, the further-improved P-51D/Mustang IV with the classic teardrop canopy arrived. This type rapidly became the Eighth Air Force's main fighter, with the range and performance to escort American bombers deep into Germany and take on the fighters of the German air force.

A taxiing Mustang being directed over a steel matting runway on Iwo Jima, 1945

A flight of Mustangs over Ramitelli air base, Italy, March 1945

Although later, more powerful models such as the P-51H were developed, the P-51D remained the definitive version, being used by the USAF during the Korean War and only being withdrawn from front-line service in 1953. Nearly 30 air forces around the world used P-51s, in over 20 variants. The Dominican Air Force was the last to retire the Mustang from service, in 1984, although many examples still fly around the world in private hands.

USAAF F-6As, the reconnaissance version of the P-51, photograph a Normandy beach prior to the invasion

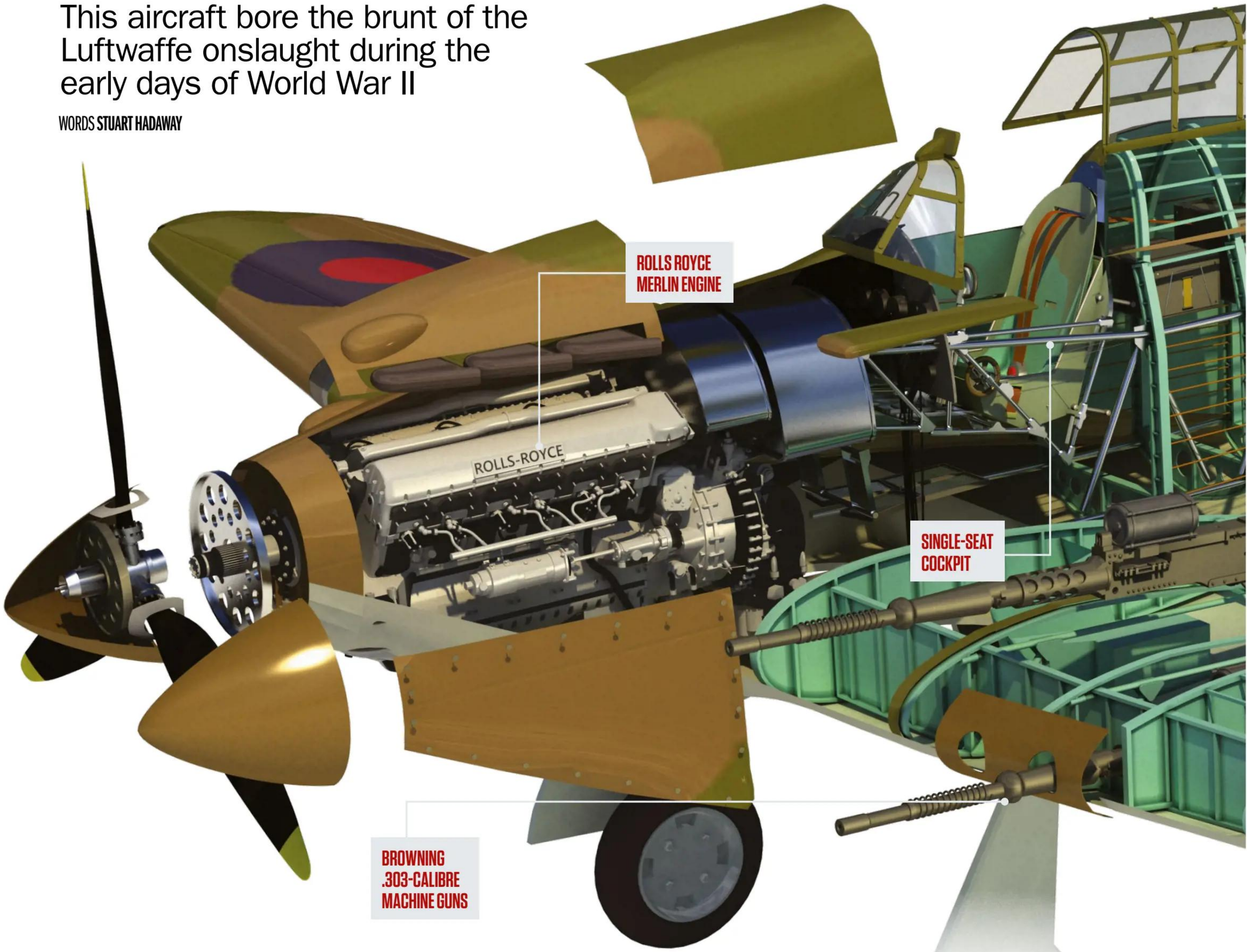
"ITS EXCELLENT LOW-LEVEL PERFORMANCE MADE IT IDEAL FOR PHOTO-RECONNAISSANCE AND GROUND ATTACK WORK OVER OCCUPIED EUROPE"

Images: Alamy, Getty

HAWKER HUR

This aircraft bore the brunt of the Luftwaffe onslaught during the early days of World War II

WORDS **STUART HADAWAY**



Although its legacy exists in the shadow of its RAF cohort, the Supermarine Spitfire, the Hawker Hurricane was the workhorse of Fighter Command early in World War II. At the beginning of the Battle of Britain, in late summer 1940, half the squadrons of Fighter Command were equipped with Hurricanes, while only 20 were flying the Spitfire. The remainder were assigned the inferior and vulnerable Boulton Paul Defiant.

The Hurricane also wrote heroic chapters in the aerial defence of the island of Malta in the Mediterranean, in North Africa, and on the European continent, as the Nazi war machine invaded France and the Low Countries and the British Expeditionary Force required tactical air support. Throughout the war, the Hurricane was also the mainstay of Commonwealth air forces in the Far East.

The first operational monoplane RAF fighter, the Hurricane was also the first such aircraft to exceed an airspeed of 480 kilometres per hour (300 miles per hour), tracing its origin to 1933, when work began on the Hawker Fury monoplane powered by a Rolls Royce Goshawk engine. The following year, the Air Ministry issued specifications for a new fighter. A design conference was held a few months later, and the prototype flew on 6 November 1935.

The Hurricane entered service with No. 111 Squadron at Northolt in December 1937, and the aircraft was modified on several occasions,

RICANE

***Above:** The Hawker Hurricane, one of the RAF's most successful fighters*

FUSELAGE OF DURALUMIN AND WOOD

with the addition of self-sealing fuel tanks, additional underwing drop tanks, alterations for service in desert and tropical climates, and racks that carried up to two 227-kilogram (500-pound) bombs for the fighter-bomber role.

In September 1944, the last Hurricane built in Britain was delivered to the RAF. More than 14,000 were completed, 12,950 by Hawker and Gloster Aircraft Company in Britain. More than 1,000 were built in Canada by the Canadian Car & Foundry Co.

HAWKER HURRICANE

COMMISSIONED:	1937
ORIGIN:	BRITISH
LENGTH:	9.75M (32 FT)
RANGE:	740KM (460 MI)
ENGINE:	1,030-HORSEPOWER, LIQUID-COOLED V-12 ROLLS-ROYCE MERLIN II OR III
CREW:	1
PRIMARY WEAPON:	8 X BROWNING .303-CALIBRE MACHINE GUNS
SECONDARY WEAPON:	2 X 113-KG (250-LB) OR 227-KG (500-LB) BOMBS

Illustration: Alex Pang

During the Battle of Britain, Hurricane squadrons performed admirably

***Above:** Early versions used available materials in order to bring the Hurricane into service as World War II loomed*

***Above:** This Hurricane has been modified to take on the fighter-bomber role*

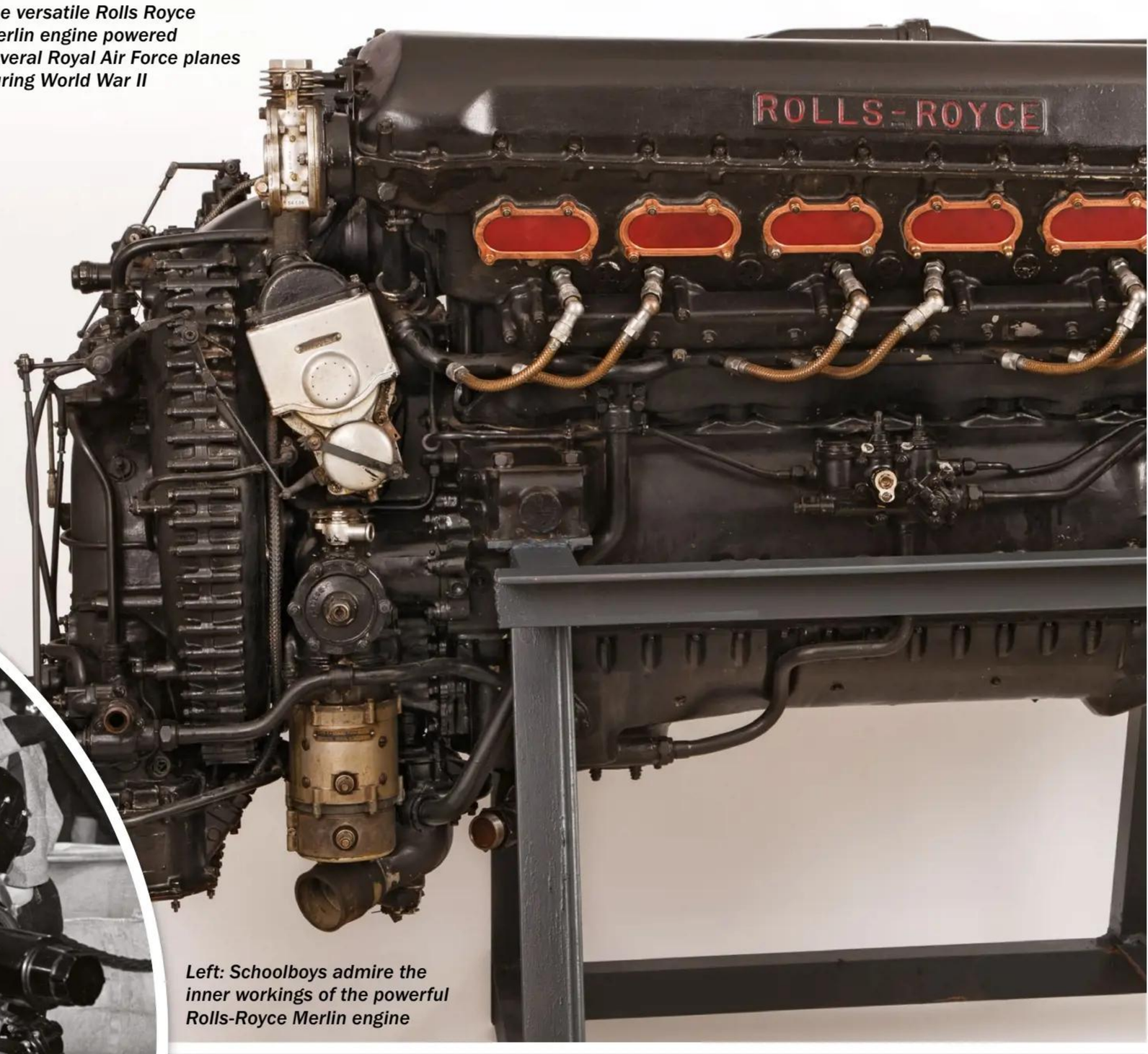
"THE VERSATILE MERLIN WAS ONE OF THE MOST SUCCESSFUL AIRCRAFT ENGINES OF WORLD WAR II"

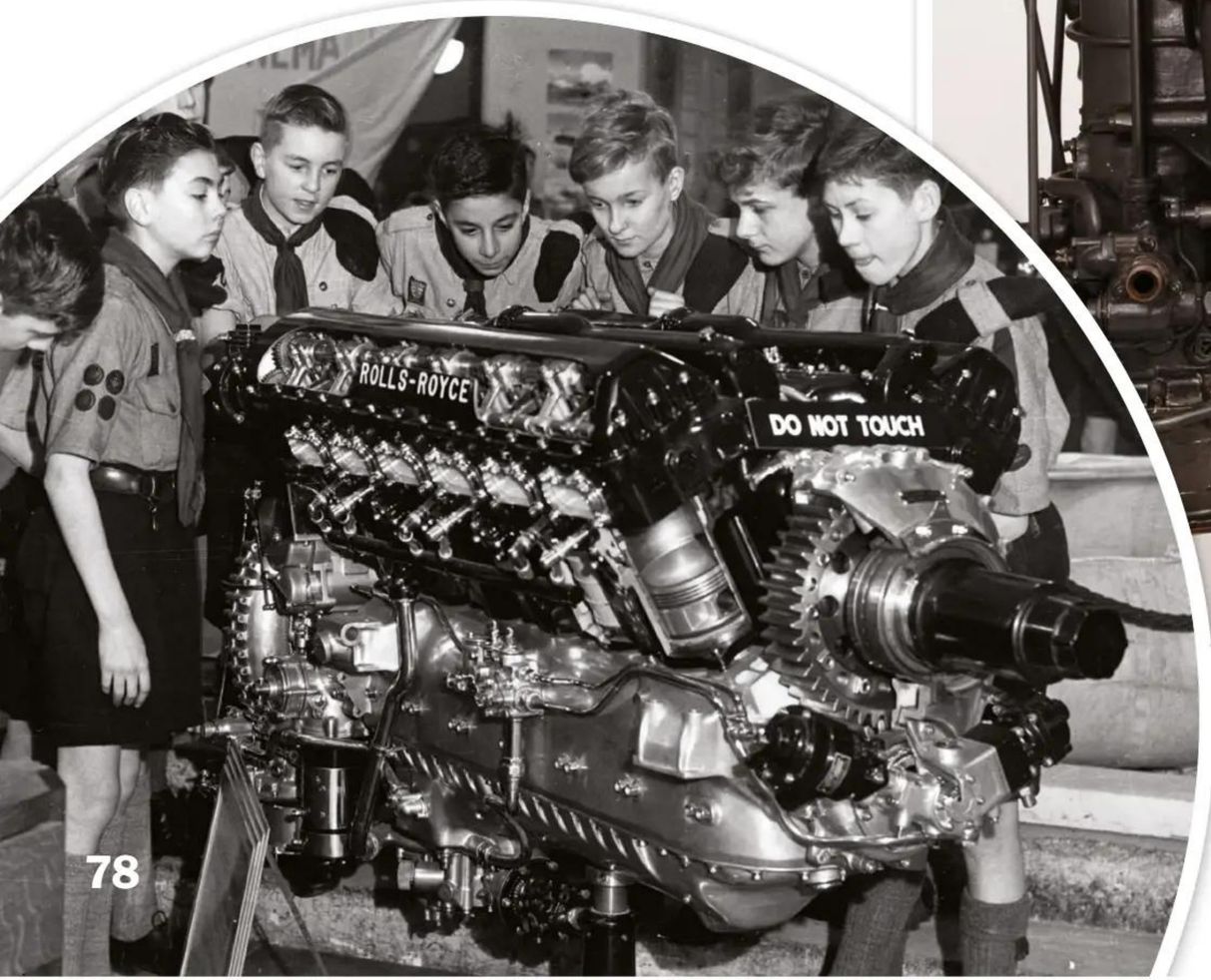
ENGINE

The Rolls Royce Merlin was a liquid-cooled, 12-cylinder inline aircraft engine developed in the early 1930s, with its first run on 15 October 1933. The versatile Merlin was one of the most successful aircraft engines of World War II, also powering the Avro Lancaster bomber, Supermarine Spitfire fighter, and improving the performance of the North American P-51 Mustang fighter.

The Merlin delivered 1,030 horsepower, giving the Hurricane a top speed of 512 kilometres per hour (318 miles per hour). Performance improved throughout the war, and nearly 1,500 were built at Rolls Royce factories in Glasgow, Derby and Crewe, and in Ford of Britain's Trafford Park facility near Manchester.

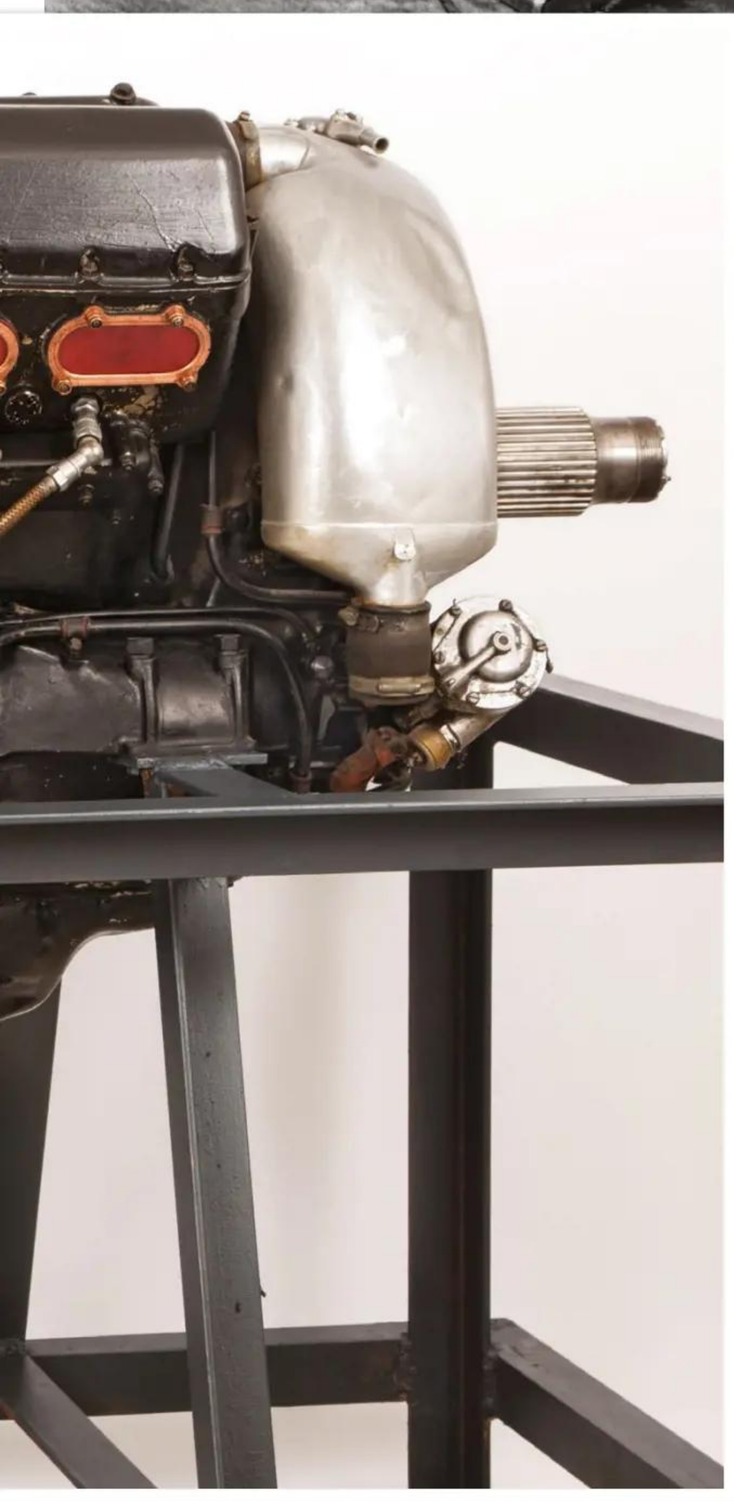
The versatile Rolls Royce Merlin engine powered several Royal Air Force planes during World War II





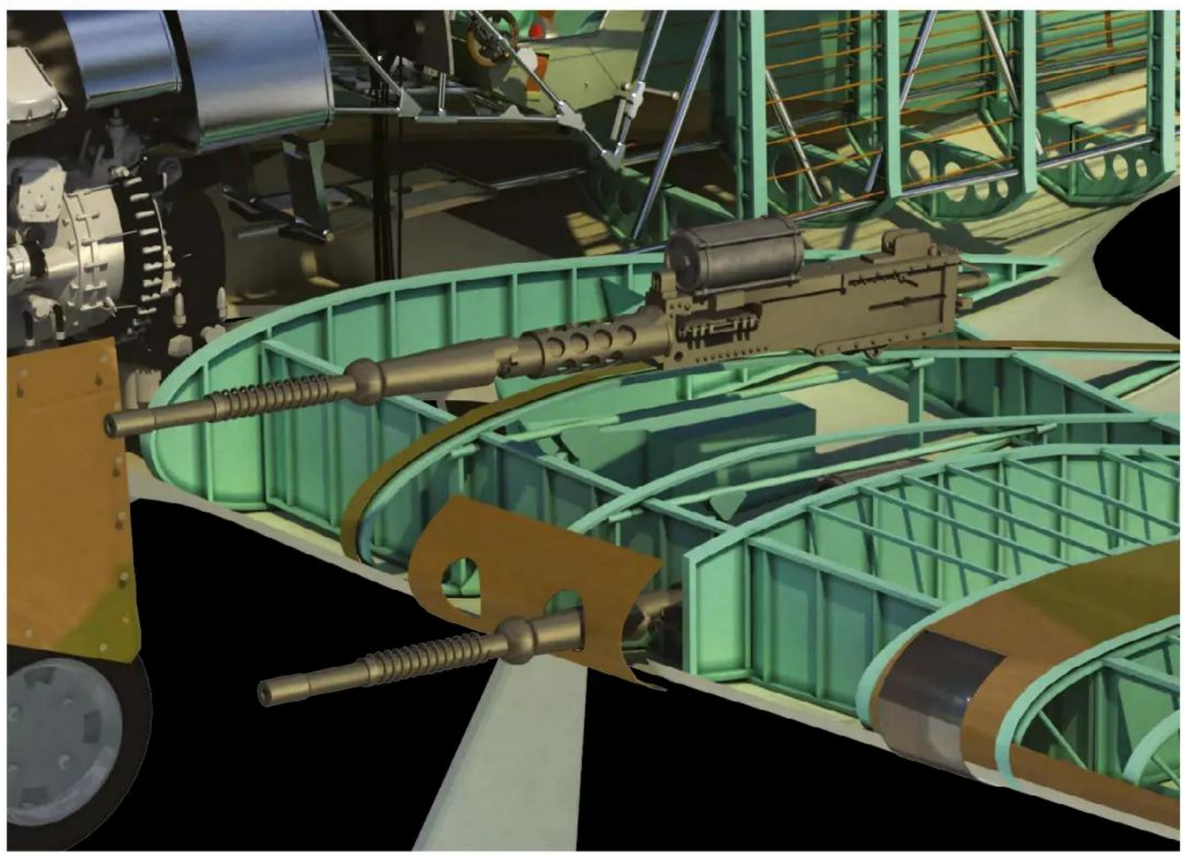
Left: Schoolboys admire the inner workings of the powerful Rolls-Royce Merlin engine

Armourers load a Hawker Hurricane's wing-mounted Browning .303-calibre machine guns



ARMAMENT

The early-production Mk. I Hurricane was armed with eight wing-mounted Browning .303-calibre machine guns, while later versions mounted a variety of weapons. The IIB, for example, was upgunned with 12 .303-calibre machine guns and racks for a pair of 113-kilogram (250-pound) or 227 kilogram (500-pound) bombs. The IIC carried four powerful Hispano 20mm cannon and retained bomb capability, while the IID mounted a pair of Vickers 40mm S guns and two .303-calibre machine guns. The Hurricane IV carried two 40mm S guns, two .303-calibre machine guns and a pair of 227-kilogram bombs. Later variants proved to be effective tank-busting aircraft.



***Above:** .303-calibre Browning machine guns featured in several variants of the Hurricane*

"THE EARLY-PRODUCTION MK I HURRICANE WAS ARMED WITH EIGHT WING-MOUNTED BROWNING .303-CALIBRE MACHINE GUNS"

Female workers assemble the components of a Hawker Hurricane on the factory floor

DESIGN

Aircraft designer Sir Sydney Camm developed the low-wing cantilever Hawker Hurricane. Early-production aircraft wings were covered in fabric and were later replaced with stressed-skin metal wings, while the fuselage was of tubular duralumin and wood construction covered with fabric. This design aspect, at first an expedient to get the fighter into service, remained unchanged throughout production. The Hurricane was relatively heavy – a sturdy and stable gun platform. However, it was slower than the Spitfire and the German Messerschmitt Me 109. Its service ceiling of 34,000 feet was lower than the Me 109, and the pilot had to contend with a blind spot that made the Hurricane vulnerable to attack from the rear.

Sir Sydney Camm led the design team that developed the Hawker Hurricane

COCKPIT

The tight but efficient Hawker Hurricane cockpit included a standard instrument panel directly in front of the pilot's seat with the stick centred. The battery voltage strength indicator was to the left, with elevator and rudder trim control at lower left and throttle at upper left, along with fuel tank selectors for main and reserve supplies. The airspeed indicator, artificial horizon, vertical speed indicator, altimeter, direction gyroscope and turn and slip indicator were located left to right in a double row in the forward panel. Engine instruments, including boost gauge, oil pressure and temperature indicators, as well as the fuel pressure indicator, were to the right on the panel.

The cockpit placed a standard instrument panel directly in front of the pilot and in close proximity to the stick

SERVICE HISTORY

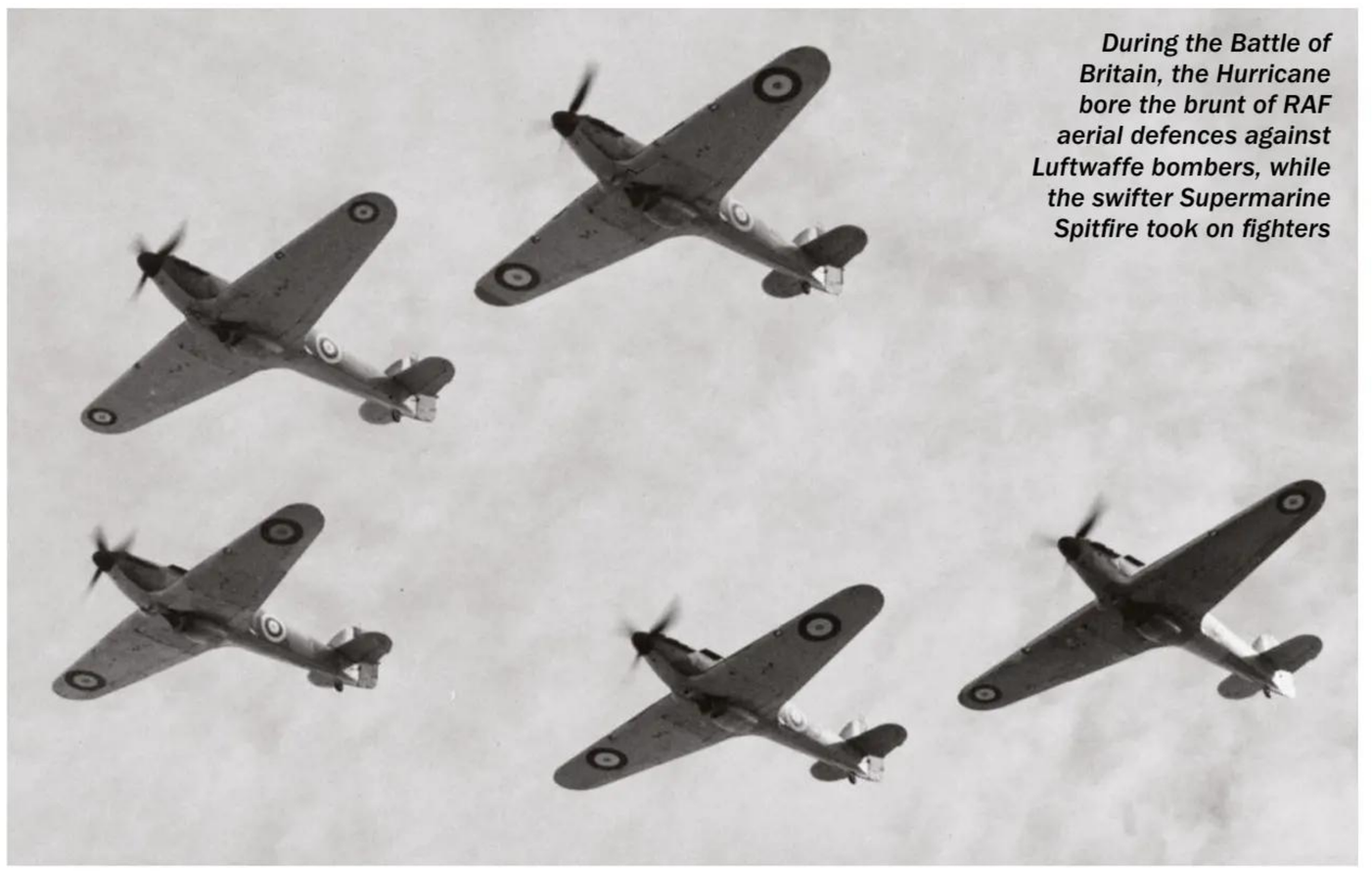
QUIET VICTOR IN THE BATTLE OF BRITAIN, THE HAWKER HURRICANE SERVED IN EVERY RAF THEATRE OF WWII

While the Supermarine Spitfire cut a dashing figure over Britain, the Hawker Hurricane might best be described as the not-so-comely stepsister. Nevertheless, the Hurricane held the line during the dark days of the Battle of Britain, shooting down more German aircraft than any other plane in RAF service. Hurricanes of No. 615 Squadron alone claimed nearly 100 enemy planes.

Although less manoeuvrable than the German Me 109 fighter and considerably slower, the Hurricane could take severe punishment. Superior range also allowed it to remain airborne longer than its adversary. Compensating for the Hurricane's shortcomings as a dogfighter, RAF pilots developed effective tactics: the Hurricanes attacked German bombers, while the more nimble Spitfires tangled with enemy fighters.

On 17 August 1940, Flight Lieutenant J.B. Nicolson of No. 249 Squadron earned the Victoria Cross, shooting down an Me 110 fighter despite grievous wounds and flames streaking from his damaged Hurricane. Wing Commander Robert Stanford Tuck of No. 257 Squadron and Sergeant Josef Frantisek of No. 303 Squadron were leading Hurricane aces during the Battle of Britain. The highest-scoring Hurricane ace of World War II was Squadron Leader Marmaduke 'Pat' Pattle with 35 victories in the Mediterranean.

Despite its shortcomings, pilots praised the Hurricane. "It became a good friend right from the start," one related, "and I loved it more and more."

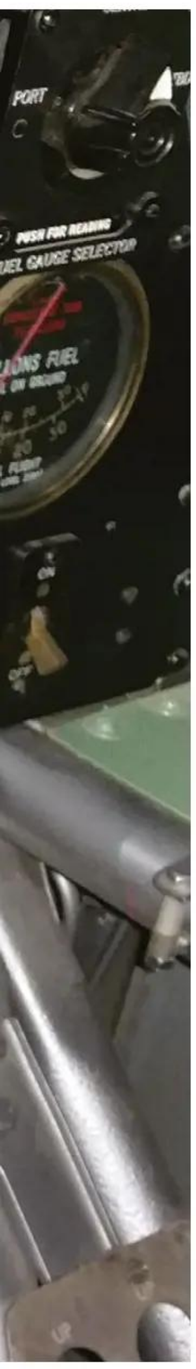


During the Battle of Britain, the Hurricane bore the brunt of RAF aerial defences against Luftwaffe bombers, while the swifter Supermarine Spitfire took on fighters

"DESPITE ITS SHORTCOMINGS, PILOTS PRAISED THE HURRICANE. 'IT BECAME A GOOD FRIEND RIGHT FROM THE START,' ONE RELATED, 'AND I LOVED IT MORE AND MORE'"

In 1941, RAF Squadrons No. 81 and No. 134 flew with the Soviet Red Air Force on the Eastern Front. In the China-Burma-India theatre, Hurricanes of No. 20 Squadron destroyed 13 Japanese tanks in a memorable mission. Hurricanes were outfitted as night fighters and were also catapulted from merchant ships, providing air cover for trans-Atlantic convoys.

The Hurricane's service life stretched into the 1950s with the air forces of at least 25 countries. From 1945 to 1959, a single Hurricane was afforded the honour of leading the annual RAF fly-past over London to commemorate the Battle of Britain.



A Hurricane swoops down in a steady dive as its pilot acquires a ground target

Images: Alamy, Getty, Ken LaRock

MESSERSCHMITT ME 262

WORDS **MICHAEL HASKEW**

The first operational jet fighter heralded a new era of aviation, but failed to make a significant impact on the war

In the summer of 1944, Allied bombers found themselves facing a new, terrifying threat to their raids over Nazi Germany. This sleek, streamlined aircraft was capable of speeds unseen before in aerial combat, making propeller-powered craft appear sluggish by comparison. Few of the bewildered Allied aircrew could have guessed it at the time, but what they were encountering, and fighting off as best they could, was the harbinger of jet-powered warfare: the Me 262.

Although jet technology made its debut on the battlefield relatively late in the war, engineers in Britain, America and Germany had been frantically developing and refining these next-generation engines since at least the late 1920s. While Britain's Frank Whittle formed the earliest turbojet engine designs, it was Germany's Hans von Ohain who completed the first practical jet aircraft, the He 178, in 1939. Coincidentally, the He 178 saw its first test flight just days before the invasion of Poland.

For much of the war, lack of proper materials, as well as politics, hampered the development of Germany's first functional jet fighter. Although test flights of the Me 262 began around 1942, with mixed success, the first aircraft would not enter combat for another two years.

In the air, pilots encountered trouble with the engine turbines, which struggled to remain intact under the sheer power of the jet propulsion. Additionally, after the invasion of the Soviet Union in 1941, there was little patience among the Nazi hierarchy for a costly, experimental aircraft.

MESSERSCHMITT ME 262

MANUFACTURER:	MESSERSCHMITT
ROLE:	FIGHTER
MAXIMUM SPEED:	870 KP/H (541 MPH)
MAXIMUM RANGE:	1,049 KILOMETRES (652 MILES)
ENGINE:	TWIN JUNKER JUMO 004B
CREW:	1
WEAPONS:	4 X 30MM MK 108 CANNONS

"PILOTS ENCOUNTERED TROUBLE WITH THE ENGINE TURBINES, WHICH STRUGGLED TO REMAIN INTACT UNDER THE SHEER POWER OF THE JET PROPULSION"

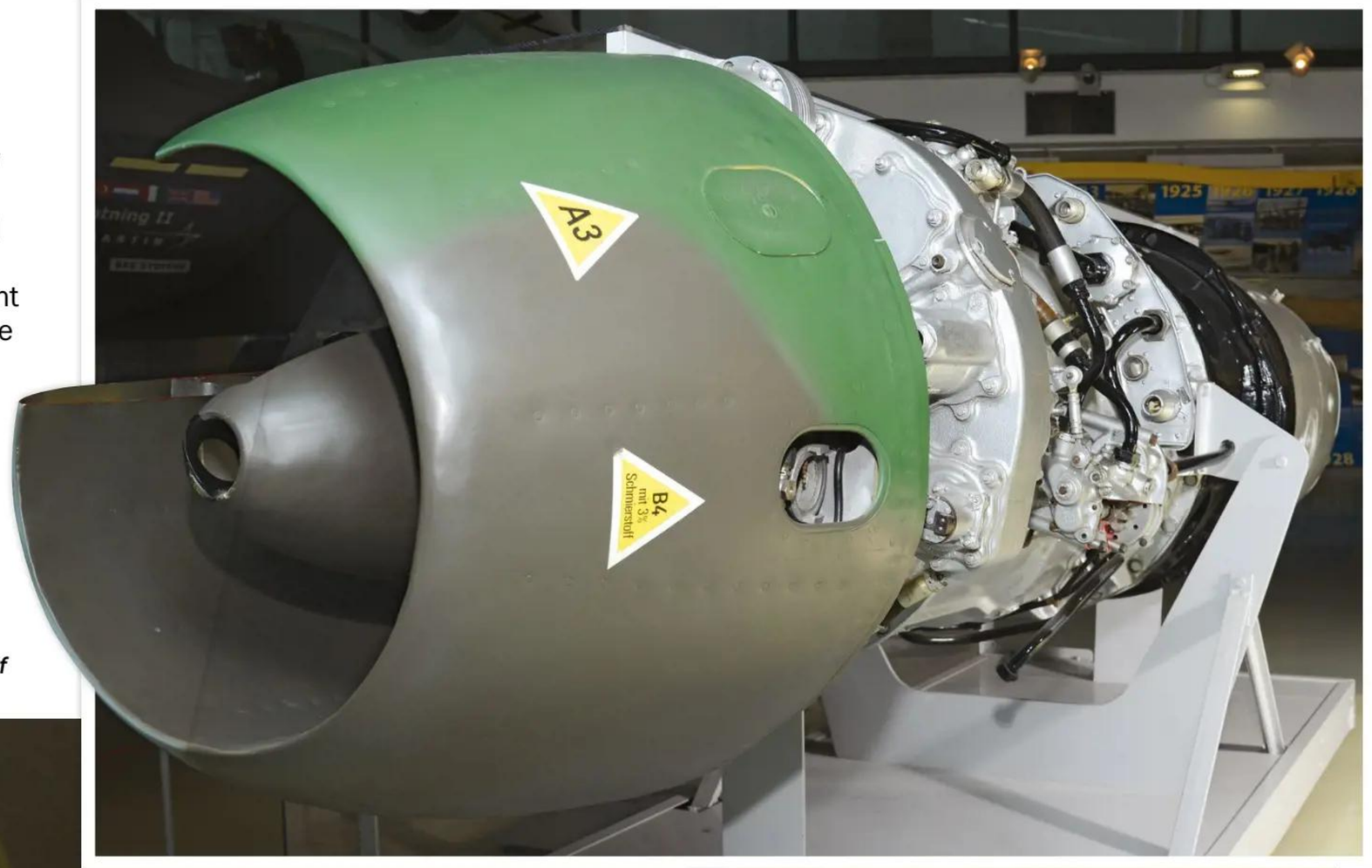
Shown in a menacing dive, the Me 262 jet fighter outclassed all contemporary Allied fighters in speed and manoeuvrability

The Me 262 incorporated a tricycle landing gear, which was common to other experimental jets of the Third Reich

Although the Me 262 was nicknamed the Schwalbe, or Swallow, the sharp nose also gave it a shark-like appearance

ENGINES

The Junkers Jumo 004B was the world's first production turbojet engine, and Junkers Motoren (Jumo) manufactured approximately 8,000 of them in Germany during World War II. A pair of these powerful engines delivered a combined 1.34 tons (2,968 pounds) of thrust, providing the Me 262 with a significant advantage in speed over Allied fighters. Three types of fuel were utilised, including diesel, high-octane aviation gasoline and coal-based J-2 synthetic. Development of the Jumo 004B began in the mid 1930s, however, turbine blade failures and other issues delayed full production until 1944. After the war, the Soviet Union continued to produce operational Jumo 004 engines.



***Right:** Its covering stripped away, the inner workings of the Junkers Jumo 004B are revealed*

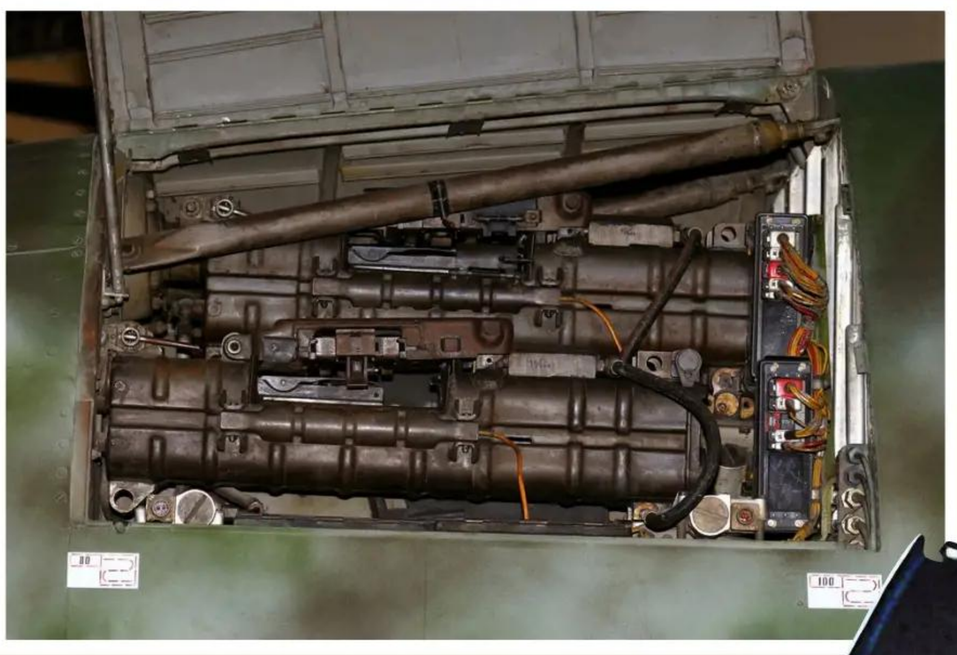
The massive air intake at the forward section of the burly Junkers Jumo 004B engine nacelle directed current through the structure

"A PAIR OF THESE POWERFUL ENGINES DELIVERED A COMBINED 1.34 TONS (2,968 POUNDS) OF THRUST, PROVIDING THE ME 262 WITH A SIGNIFICANT ADVANTAGE IN SPEED OVER ALLIED FIGHTERS"

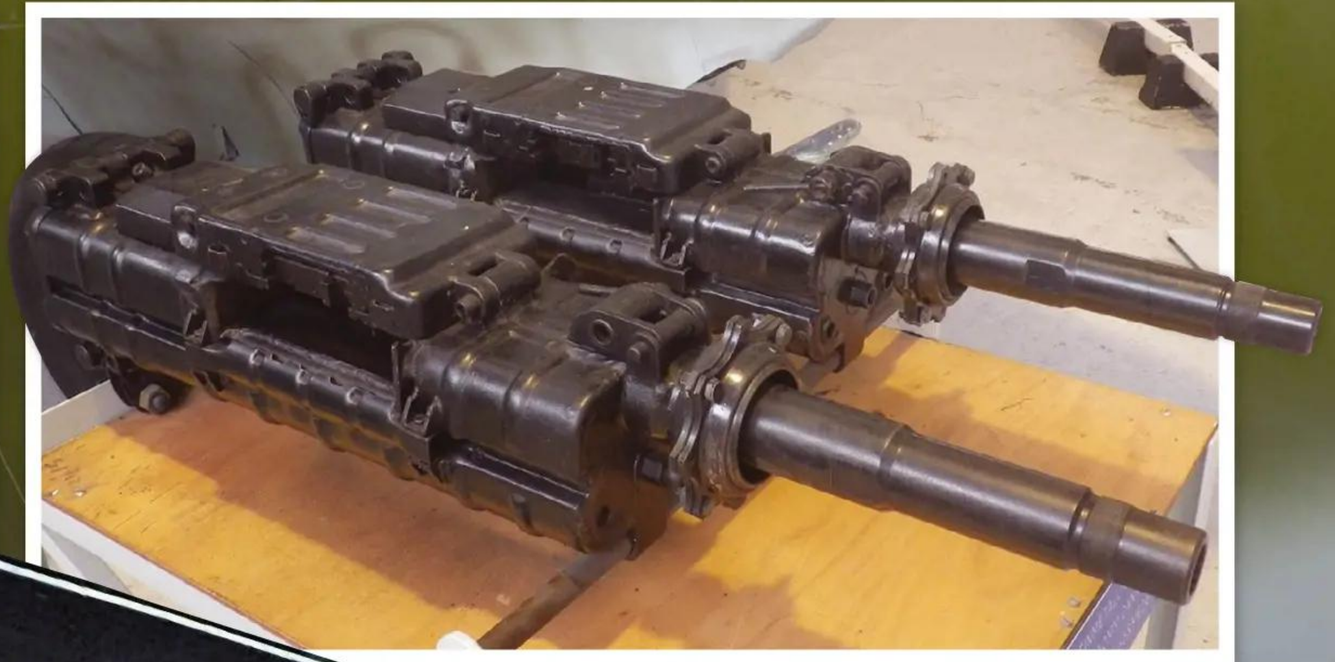
***Below:** This cutaway photograph reveals the troublesome turbine fan blades that delayed development of the Junkers Jumo 004B jet engine*

The nose of the Me 262 jet fighter housed lethal Rheinmetall-Borsig Mk 108 30mm autocannon that fired through the cowling

***Below:** Stacked inside the nose cowling of the Me 262, four Mk 106 30mm autocannons were serviced from each flank*



***Below:** Although it possessed relatively low muzzle velocity and rate of fire, the Mk 108 30mm autocannon was devastating against enemy aircraft*



ARMAMENT

Without a government contract, arms manufacturer Rheinmetall-Borsig began developing the potent Mk 108 30mm autocannon for combat aircraft in 1940. Soon, the German Air Ministry observed its robust firepower, and production began in 1943. Although low muzzle velocity limited its range, the weapon was effective, particularly in combination with the speedy Me 262 jet fighter, which mounted up to four cannon in its nose cowling. However, the pilot was required to demonstrate superior flying skill to avoid a collision while closing with his target. The Mk 108 required an average of only four hits to destroy Allied heavy bombers.

"THE PILOT WAS REQUIRED TO DEMONSTRATE SUPERIOR FLYING SKILL TO AVOID A COLLISION WHILE CLOSING WITH HIS TARGET"

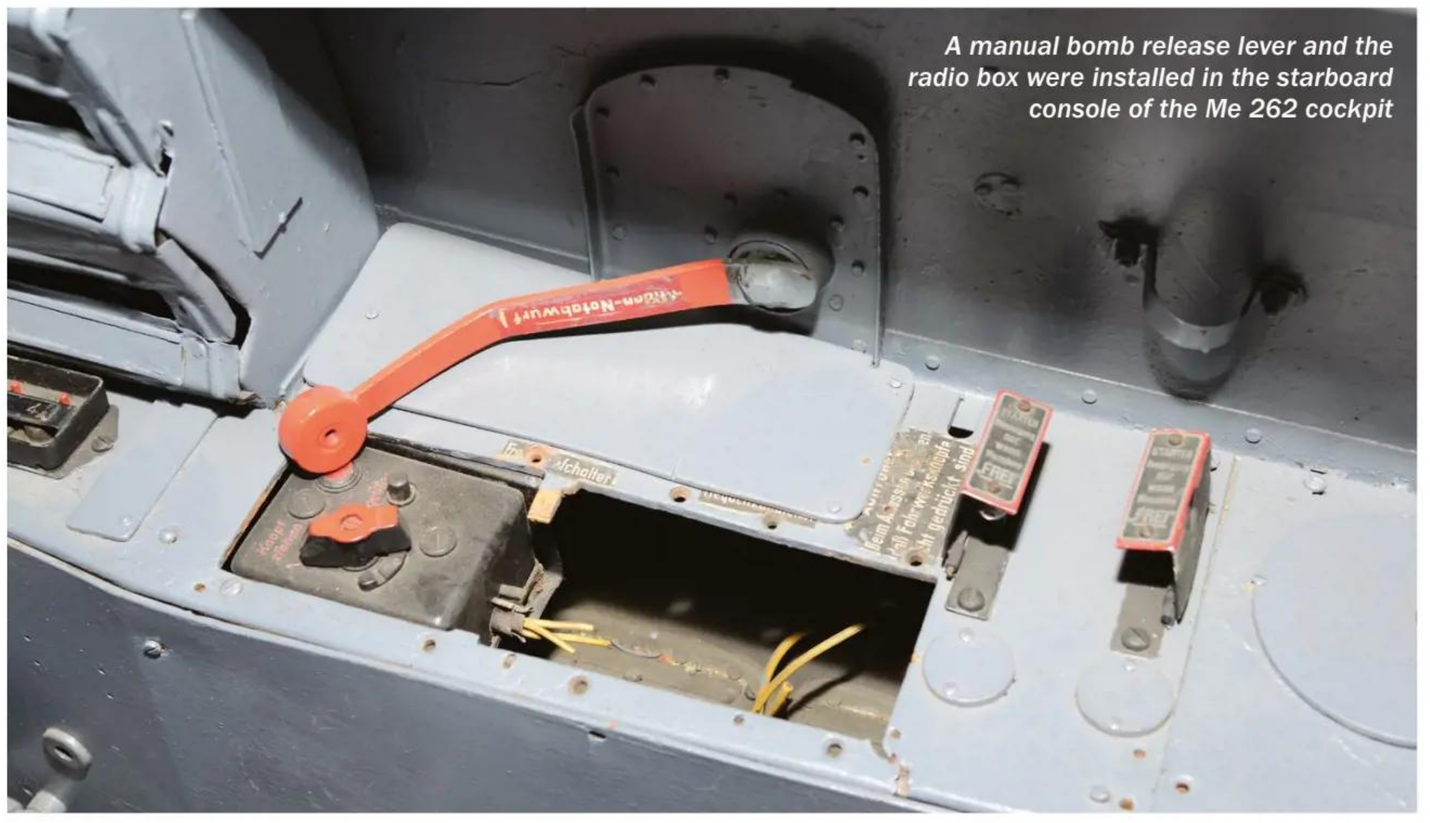
An armourer services one of the Mk 108 30mm autocannons aboard a night fighter variant of the Me 262

“THE 90MM-THICK ARMOURED GLASS WINDSCREEN WAS COMPLETE WITH ELECTRIC HEAT FOR DE-ICING”

The main instrument panel of the Me 262 cockpit allowed the pilot to view flight characteristics, gauges and armament controls

COCKPIT

The cockpit of the Me 262 was similar to other Messerschmitt aircraft of World War II. The pilot’s seat and rudder pedals were adjustable; the 90mm-thick armoured glass windscreen was complete with electric heat for de-icing; the Revi 16B gunsight, stowed for takeoff and landing, was mounted inside the windscreen; the control column carried a spring-loaded safety device covering firing buttons that operated the 30mm cannon, along with buttons for bomb release, breechblock clearing and radio transmission; and the main instrument panel included the flight panel on the upper left, the armament control panel directly below and the engine performance indicators and gauges on the right.



A manual bomb release lever and the radio box were installed in the starboard console of the Me 262 cockpit

DESIGN

The sleek, aerodynamic silhouette of the Me 262 foreshadowed the designs of future jet fighters, including a low-profile canopy to reduce drag and slightly swept wing construction implemented to balance the centre of gravity when the twin Junkers Jumo 004 jet engines, originally wing-root mounted, were later moved to wing pods. The fuselage was composed of several sections bolted together and the tricycle landing gear configuration was common to other early Luftwaffe jets. The design also contributed to overall performance, allowing the Me 262 to hold its airspeed longer in tight turns than conventional prop-driven planes, a distinct advantage in combat.

The development of the sleek Me 262 twin-engine jet fighter was delayed due to Hitler's constant meddling

SERVICE HISTORY

THE MOST ADVANCED AIRCRAFT OF WORLD WAR II, THE ME 262 ENTERED SERVICE TOO LATE TO INFLUENCE THE OUTCOME OF THE CONFLICT

When the Luftwaffe General of Fighters, Adolf Galland, flew the new Me 262 jet fighter, he was exhilarated, reporting, "It felt as if angels were pushing."

Indeed, the Me 262 was revolutionary, capable of outperforming Allied propeller-driven fighters and potentially devastating the formations of heavy bombers raining destruction on German cities and industrial centres as World War II progressed.

However, due largely to Hitler's meddling and the lack of firm commitment from the German Air Ministry to its development, the Me 262 did not enter frontline service until the spring of 1944.

Although more than 1,400 were built, fewer than 300 Me 262 aircraft were believed to be operational with the Luftwaffe at any given time. The versatile jet, nicknamed Schwalbe, or Swallow, was employed as a light bomber, actually attacking the American bridgehead across the Rhine River in March 1944, and as a legendary fighter, outclassing contemporary Allied planes in speed and manoeuvrability.

During World War II, a total of seven Luftwaffe units – most notably Kommando Nowotny, also known as Jagdgeschwader 7 (JG 7) – flew the Me 262 in combat.

Named for its commander, Major Walter Nowotny, JG 7 developed the tactics to be employed with the new jet fighter. Nowotny was credited with 258 aerial victories during the war, three of them while piloting the Me 262. He died when he crashed his jet after an air battle with American fighters on 8 November 1944.

By the end of World War II, 28 Luftwaffe pilots had achieved 'ace' status, with five or more kills while flying the innovative aircraft, and Me 262 pilots were believed to have destroyed approximately 200 Allied planes. During the late 1940s, American and Soviet engineers put captured German jets through their paces, and the Me 262 design influenced succeeding generations of military aircraft.

The Me 262 jet fighter's narrow cockpit was ergonomically functional in the arrangement of the control stick, instrument panel, and canopy

Images: Getty, Wiki / PD / Gov

COLD WAR & BEYOND

GLOSTER METEOR FR.9

90 The tactical reconnaissance jet fighter that saw action in Europe and the Middle East

GENERAL DYNAMICS F-111 AARDVARK

96 An American fighter jet that would become synonymous with the Vietnam and Gulf Wars

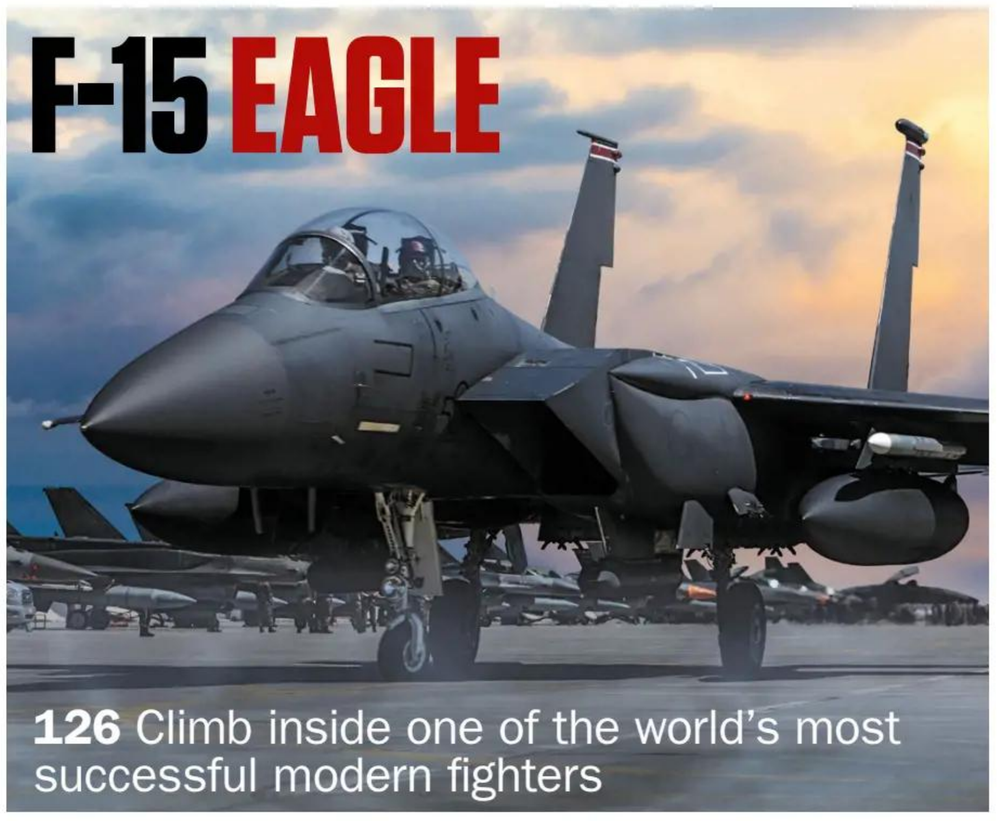
BRITISH AEROSPACE HARRIER GR9

GRUMMAN F-14D TOMCAT

BLACKBURN BUCCANEER S2

PANAVIA TORNADO

F-15 EAGLE



GLOSTER METEOR

This aircraft was the tactical reconnaissance version of the RAF's first jet fighter, and saw service in Europe and the Middle East

WORDS **STUART HADAWAY**

CRAMPED COCKPIT
The cockpit of the Meteor was cramped and crowded. Ejecting could be hazardous, with lots of ways to get cut or even break bones.

NOSE SECTION
The only major design change in the FR.9 was the camera compartment, with multiple windows for aiming the equipment.

The Gloster Meteor FR.9 was one of the final versions of the RAF's first jet fighter, which had originally entered service in July 1944. The aircraft had come a long way in a short time. When it entered service in 1950, the FR.9 had engines that were twice as powerful as the original Meteor, and it could go half as fast again.

The FR.9 was intended to replace the Supermarine Spitfire FR.18, as the RAF moved towards an all-jet front line. After an incredibly short design and acceptance process, the first

EOR FR.9

OLD-FASHION DESIGN

The Meteor was unimaginative in design, without the radical lines of some contemporary jet aircraft. However, this sped up testing and production.

The Gloster Meteor was Britain's first jet fighter, entering service in 1944

SIMPLE BUT EFFECTIVE AIRFRAME

The Meteor's classic monocoque airframe was old-fashioned in some ways, but it was simple, easy to produce and versatile.

GLOSTER METEOR FR.9

COMMISSIONED:	1950
ORIGIN:	BRITISH
LENGTH:	13.6M (44FT 7IN)
RANGE:	1,110KM (684MI)
ENGINE:	2 X 1,587KG (3,500LB) THRUST ROLLS-ROYCE DERWENT 8
CREW:	1
WEAPONS:	4 X HISPANO MK. V 20MM

Illustration: Alex Pang

production models entered service just months after the first prototype flew. It was quickly introduced in Europe to support the growing forces gathering to oppose the Soviets, as well as in the Middle East, where Britain was facing growing tensions in Egypt and the Persian Gulf. Designed for fast, low work over the battlefield, pilots were trained to fly at 76 metres (250 feet) for safety reasons, although it was emphasised that lower altitudes would be required in combat.

A total of 126 FR.9s were made, serving with four active squadrons and a training unit, and remained in service into the early 1960s.

The Meteor was perhaps unsophisticated, but it had clean and elegant lines

COCKPIT

The cockpit of the Meteor FR.9 was cramped and crowded. While the basic flight instruments and controls ahead of the pilot were straightforward, both sides of the cockpit wall had a mix of controls for the engines, electrics, radios and other devices. When the F.24 camera was fitted, the camera controls were on the right-hand wall, but those for the more complicated F.95 had to be moved and fitted above the left side of the instrument panel.

“BOTH SIDES OF THE COCKPIT WALL HAD A MIX OF CONTROLS FOR THE ENGINES, ELECTRICS, RADIOS AND OTHER DEVICES”

The FR.9 was a modified version of the F.8, which saw combat in Korea with the RAAF

The FR.9 retained the F.8's four 20mm cannons (pictured here), with only the extreme tip of the nose being modified to take cameras

ARMAMENT

The FR.9 carried four 20mm cannons, but its true weapons were its cameras. The nose had three windows – looking forward and to each side – but the compartment could only contain one F.24 camera, and aircraft had to pass their targets at the correct angle. The F.24 was an excellent but old camera, unsuitable for jet aircraft. In 1953 the F.95 replaced it. Small enough to have one fitted at each window (each with a 400 exposure film), this made the FR.9 a much more flexible and capable aircraft.

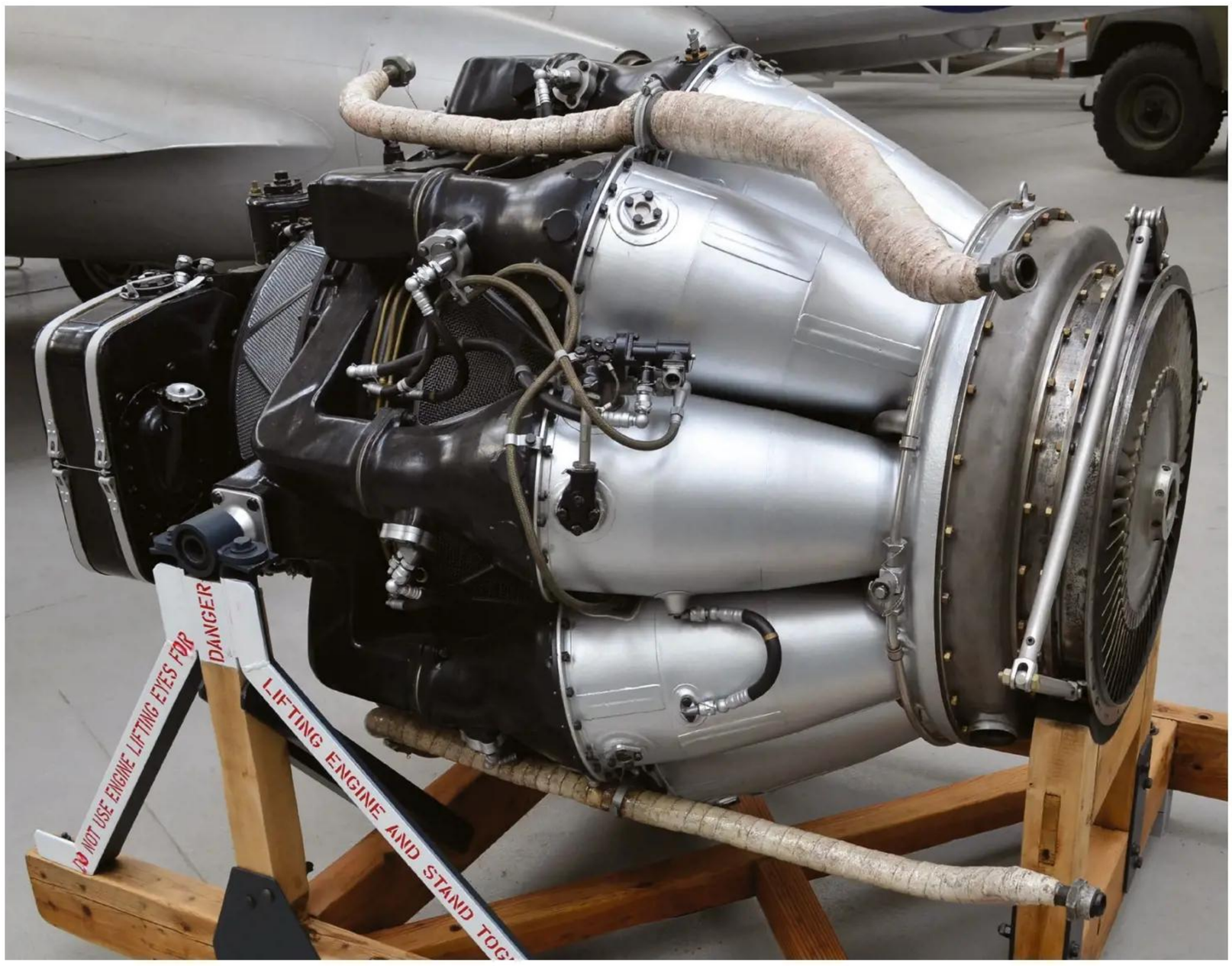
"THE FR.9 CARRIED FOUR 20MM CANNONS, BUT ITS TRUE WEAPONS WERE ITS CAMERAS"

***Right:** Cleaning the guns on a Meteor Mk. 3. This would be important in the low-flying FR.9*

ENGINE

The Rolls Royce Derwent 8 was a development of the W.2B Welland, the production model of Frank Whittle's original jet engine, which had been used to power the Meteor F.1 in 1943. The basic single-stage centrifugal flow compressor turbojet with ten combustion chambers was modified through several marques, until the Mk.8 had nearly double the thrust of the original Wellands used on the F.1, with 1,587 kilograms (3,500 pounds) of thrust. The engine and supporting systems were simple, reliable and easily maintained.

"THE MK. 8 HAD NEARLY DOUBLE THE THRUST OF THE ORIGINAL WELLANDS USED ON THE F.1"



***Right:** Simple but effective: The Rolls Royce Derwent 8 at IWM Duxford*

DESIGN

The FR.9 was based almost entirely on the F.8 fighter variant, with the addition of the camera-suitable nose cone. It kept the performance and armament of a fighter to suit its potential role over a battlefield, with the need to either defend itself or engage opportunistic ground targets. This commonality with a previous type explains the speed with which the aircraft entered service, and once in squadron service only two minor changes were made before it was retired – fitting ejector seats from December 1950 and updating the cameras in 1953.

The FR.9 was able to be quickly introduced because of its similarities to the F.8 fighter variant

The FR.9 was a basic F.8 airframe, with only the camera compartment in the nose being different

SERVICE HISTORY

THE METEOR FR.9 WAS INTRODUCED SWIFTLY AND SAW SERVICE IN SEVERAL PARTS OF THE WORLD

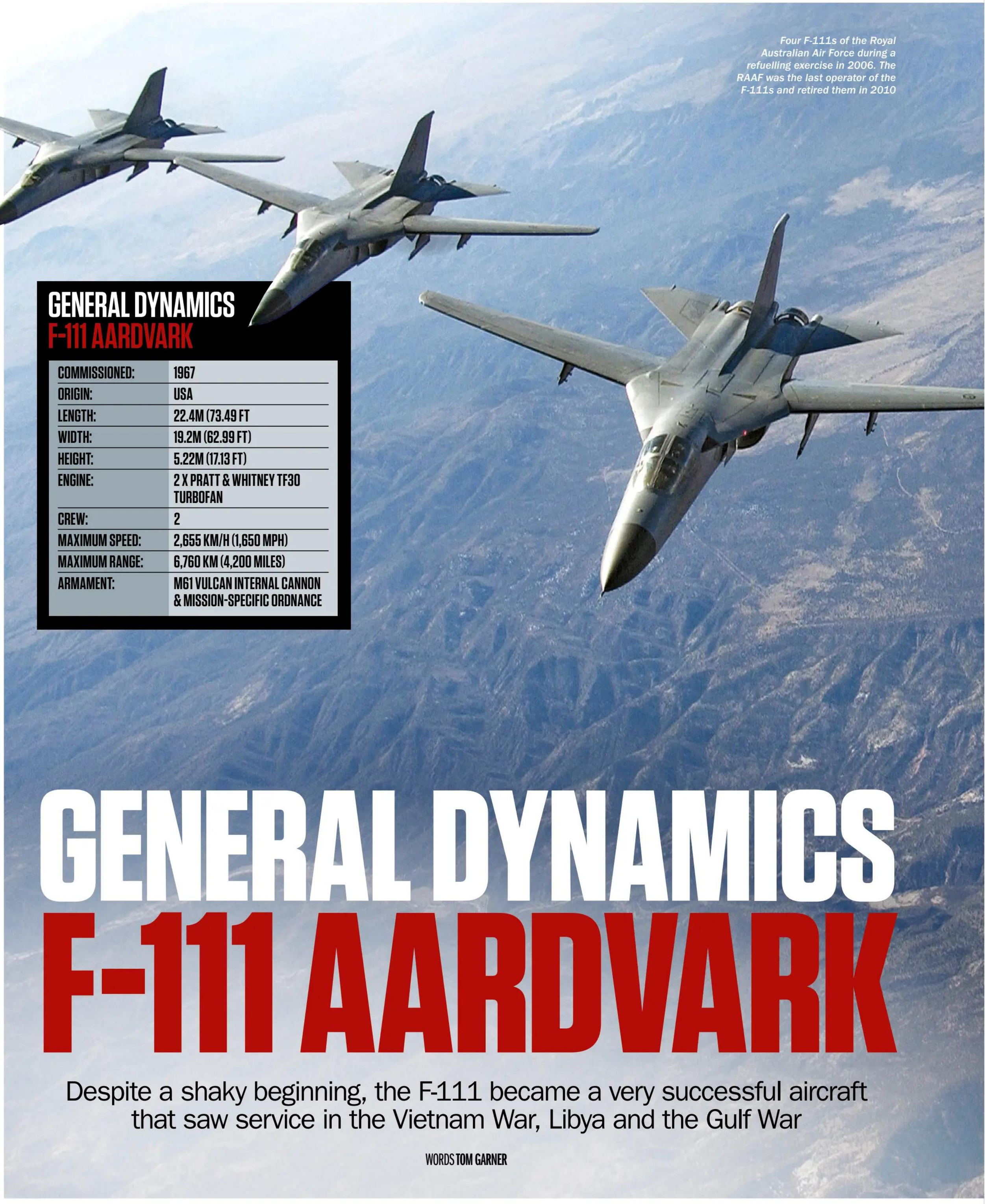
The Meteor FR.9 first flew on 22 March 1950. By the end of the year, the type entered service with No. 2 Squadron in Germany, followed by No. 208 Squadron in Egypt. In December 1951, No. 79 Squadron, also in Germany, received FR.9s, and the last frontline squadron to fly them, No. 8 Squadron in Aden, received them in 1958. Pilots trained at No. 226 Operational Conversion Unit.

The speed of introduction was due to the fact that the aircraft only had minor modifications from the Meteor F.8 fighter, which would see combat with the RAAF over Korea. Indeed, during the 1956 Suez Crisis No. 208 Squadron's FR.9s acted as fighters defending Cyprus, although without seeing action. The type gave particularly useful service in the Persian Gulf, where the British were fighting several small wars, and the last FR.9s were withdrawn from service there in 1961. Over 20 FR.9s were sold to Ecuador, Israel and Syria.

Meteor FR.9s of No. 208 Squadron in close formation over Egypt, 1951

An RAAF F.8 being serviced in 1952 in Korea. The F.8, on which the FR.9 was very closely based, saw service during the Korean War

Images: Alamy, Wiki / PD



Four F-111s of the Royal Australian Air Force during a refuelling exercise in 2006. The RAAF was the last operator of the F-111s and retired them in 2010

GENERAL DYNAMICS F-111 AARDVARK

COMMISSIONED:	1967
ORIGIN:	USA
LENGTH:	22.4M (73.49 FT
WIDTH:	19.2M (62.99 FT)
HEIGHT:	5.22M (17.13 FT)
ENGINE:	2 X PRATT & WHITNEY TF30 TURBOFAN
CREW:	2
MAXIMUM SPEED:	2,655 KM/H (1,650 MPH)
MAXIMUM RANGE:	6,760 KM (4,200 MILES)
ARMAMENT:	M61 VULCAN INTERNAL CANNON & MISSION-SPECIFIC ORDNANCE

GENERAL DYNAMICS F-111 AARDVARK

Despite a shaky beginning, the F-111 became a very successful aircraft that saw service in the Vietnam War, Libya and the Gulf War

WORDS **TOM GARNER**

The F-111 was a multipurpose American fighter-bomber that was capable of supersonic speeds and achieved one of the safest operational records of any aircraft in USAF history. It was originally designed in the early 1960s with Tactical Air Command wanting an aircraft that could operate from shorter runways. However, the task was complicated by the secretary of defence, Robert McNamara, who directed the USAF and US Navy to develop a common aircraft. Both services initially welcomed the joint fighter but there were continuous problems with fixing the plane's weight, engine and drag issues as well as escalating costs and the Navy backed out. Nonetheless, once the teething problems had been fixed, the F-111 was an outstanding aircraft.

Nicknamed 'Aardvark' because of its long-nosed appearance, its pilots described it as "a joy to fly" as it was extremely fast and gave a smooth ride, assisted by its variable sweep wings. These allowed the pilot to fly from slow approaches to supersonic speed at sea level. This impressive performance was enabled by a sophisticated radar system that flew the plane at a constant altitude following the Earth's contours. Consequently, F-111s could fly in valleys or over mountains, day or night, regardless of the weather conditions and if any of the system's circuits failed the aircraft automatically initiated a climb.

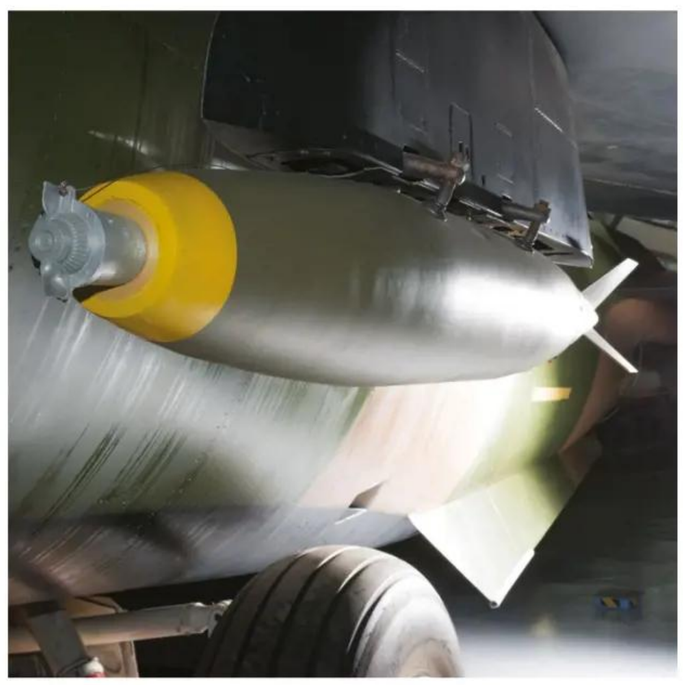
Accordingly, F-111s were perfect for low-level pinpoint strikes on heavily defended targets, flying in so fast that the enemy didn't know about an attack until the bombs exploded. One F-111 crewman who was shot down over Vietnam recalled how a Viet Cong guard quickly slashed his hand sideways and exclaimed to him, "You F-111… whoosh!"

***Above:** This F-111 was based at Upper Heyford US Air Base in Oxfordshire, England, and is now housed in the American Air Museum as part of Imperial War Museum, Duxford*

"F-111S WERE PERFECT FOR LOW-LEVEL PINPOINT STRIKES ON HEAVILY DEFENDED TARGETS, FLYING IN SO FAST THAT THE ENEMY DIDN'T KNOW ABOUT AN ATTACK UNTIL THE BOMBS EXPLODED"

ARMAMENT

The F-111 could carry up to four nuclear weapons with two of the bombs being carried in the internal weapons bay. External ordnance on the wing pylons could include up to 1,500 kilograms of bombs, missiles and rockets. To protect itself, the aircraft was defended with an M61 Vulcan internal cannon. The M61 Vulcan is a six-barrel rotary cannon, which can fire 20 mm rounds at the very high rate of 6,000 rounds per minute. It was designed in 1946 and has been in service with the US military since 1959.



***Left and below:** The F-111's arsenal was formidable and it was one of the fastest aircraft available that could drop nuclear bombs at short notice*

"EXTERNAL ORDNANCE ON THE WING PYLONS COULD INCLUDE UP TO 1,500 KILOGRAMS OF BOMBS, MISSILES AND ROCKETS"

F-111s were designed to carry different weapons. This picture from 1981 shows an F-111 mounted with concrete penetration missiles

***Left:** M61 Vulcan rotary cannon defended F-111s. Its design is based on the 19th century Gatling gun but it can fire over 6,000 rounds per minute*

An F-111A dropping 24 Mark 82 low-drag bombs over a range in Nevada in 1980

The F-111 had a crew of two, consisting of a pilot and weapons systems officer

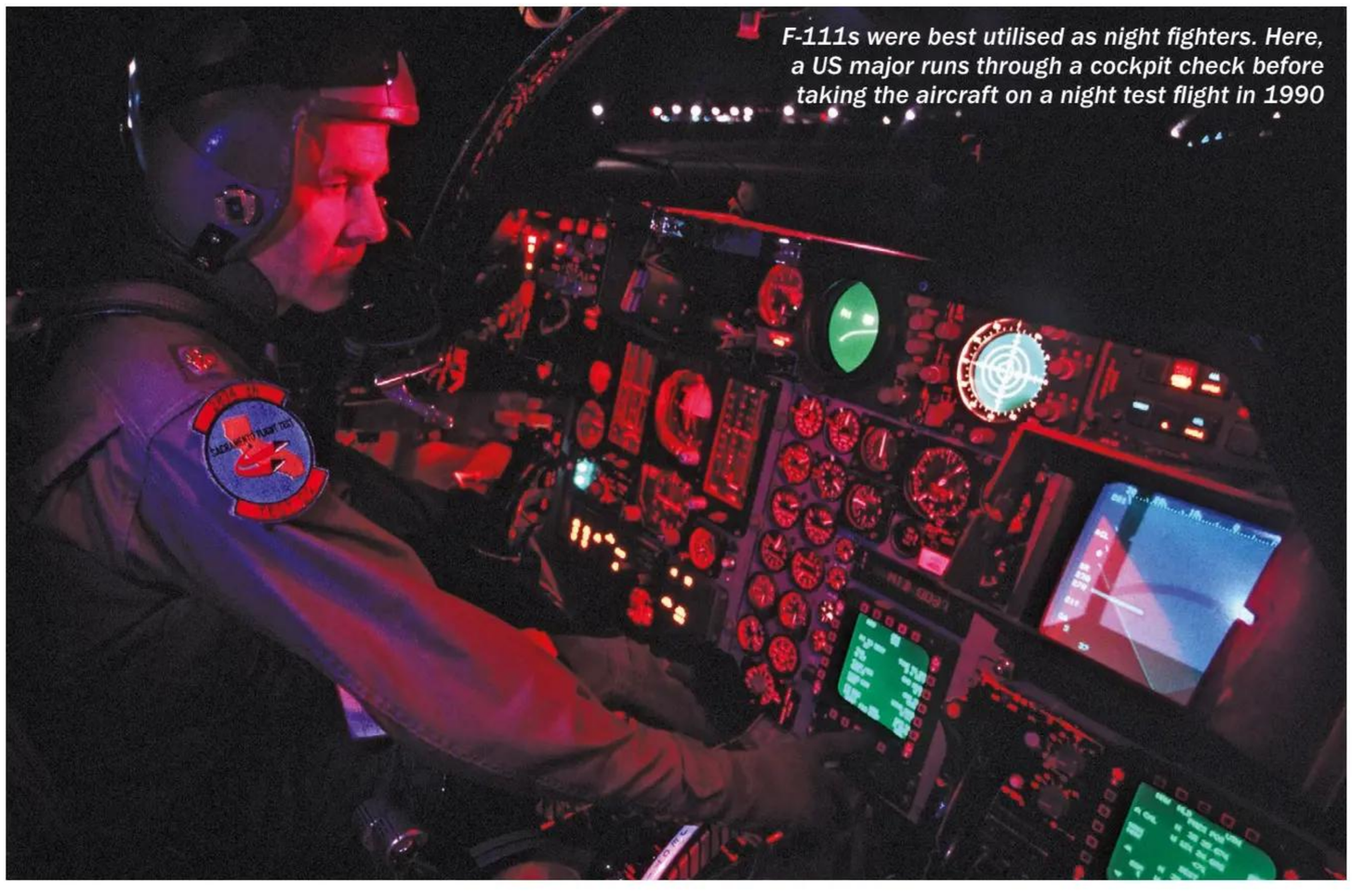
Right: *The F-111's cockpit acted as a detachable escape module in emergencies and removed the need for ejector seats*

Far right: *Once the cockpit was separated from the aircraft parachutes were deployed and the module landed on airbags*

COCKPIT

Two crew members sat side by side in an air-conditioned, pressurised cockpit that also served as an innovative emergency escape vehicle. It could act as a survival shelter on land or water. In emergencies, an explosive cutting cord separated the cockpit module from the aircraft, which then descended by parachute. Airbags then cushioned the impact and helped the module to stay afloat on water. The cockpit could be released at any speed or altitude, and even underwater. For underwater escapes, the airbags raised the module to the surface after it had been severed from the plane.

"THE COCKPIT COULD BE RELEASED AT ANY SPEED OR ALTITUDE AND EVEN UNDERWATER"



F-111s were best utilised as night fighters. Here, a US major runs through a cockpit check before taking the aircraft on a night test flight in 1990

F-111s had a complex avionics system which included communications, navigation, terrain following, target acquisition and suppression of enemy air defence systems

“THE ENGINE’S GREAT SPEED WAS MATCHED BY A CLEVER CO-ORDINATION WITH THE AIRCRAFT’S AVIONICS SYSTEM, WHICH MEANT THE F-111 COULD FLY AT MACH 1.2 AT ONLY 60 METRES”

A Royal Australian Air Force F-111C performing a ‘dump and burn’ at an air show. The fuel is intentionally ignited using the aircraft’s afterburner

***Above:** Two powerful Pratt & Whitney TF30 turbofan engines power the F-111, delivering speeds of over 2,500 km/h*

ENGINES

The F-111 was powered by two Pratt & Whitney TF30 afterburning turbofan engines, which made it capable of achieving a top speed of over Mach 2 at 2,655 kilometres per hour. When the aircraft had its maiden flight on 21 December 1964, there were engine problems including compressor surges and stalls. It took the collaboration of the USAF, General Dynamics and even NASA to fix the engine’s faults with a major inlet design, but once it was solved, the F-111 became fearsome. The engine’s great speed was matched by a clever coordination with the aircraft’s avionics system, which meant the F-111 could fly at Mach 1.2 at only 60 metres.

COMBAT SERVICE

From September 1972 to March 1973, F-111As flew over 4,000 combat sorties over Vietnam with only six combat losses. This gave the F-111A a loss rate of only 0.015 per cent, making it the most survivable aircraft of the Vietnam War. Over 40 F-111s took part in Operation El Dorado Canyon, the US retaliation raid on Libya after the Berlin bombings in 1986. They performed a night-time raid dropping 54 tonnes of munitions on strike targets with the loss of only one aircraft. Three F-111 squadrons took also part in the Gulf War flying large numbers of sorties and were credited with destroying hundreds of Iraqi vehicles and artillery pieces along with selected attacks on Iraqi command centres.

***Below:** A ground crew prepares a US F-111F for a retaliatory airstrike on Libya at RAF Lakenheath, England. The aircraft is armed with GBU-10 modular glide bombs*

An F-111F releasing its load of Mark 82 bombs. Scenes like this were repeated many times during the Gulf War

Images: Wiki / PD / Gov, Thinkstock

BRITISH AEROSPACE HARRIER GR9

The final Harrier used by the RAF is a hi-tech aviation powerhouse and an upgrade to one of the finest aircraft designs of all time

BRITISH AEROSPACE HARRIER II GR9

FIRST MANUFACTURED:	2006
ORIGIN:	BRITISH
LENGTH:	14.36M (47FT)
MAXIMUM SPEED:	574 KNOTS (660MPH)
MAXIMUM ALTITUDE:	13,106M (43,000FT)
THRUST:	21,750LBS
ENGINE:	RR PEGASUS 105 TURBOFAN
CREW:	1
ARMAMENT:	AIM-9L SIDEWINDER, MAVERICK, PAVEWAY II, PAVEWAY III, ENHANCED PAVEWAY, GENERAL PURPOSE BOMBS, CRV-7 ROCKET POD

Images: Wiki / PD / Gov

One of Britain's most celebrated engineering innovations of the last century, the Harrier's unique design has made it a deadly war machine and a global icon. First appearing in 1957, and followed by many updated versions, by 1980 the line was in need of a shakeup, so the USA and UK agreed on a £184 million ($280 million) project – the result was the Harrier II. Before its later purchase by the US AV-8B fleet, it served in Kosovo, Iraq and Afghanistan on the Invincible class of aircraft carrier.

An ideal machine for both attack and reconnaissance missions, the Harrier II was deployed frequently by NATO to deter violence after the collapse of Yugoslavia. Later in its life, the aircraft was joined by Sea Harriers in a new line-up known as Joint Force Harrier.

During the Invasion of Iraq, the British action worked under Operation Telic and at the Battle of Basra. Here, Harriers destroyed many Scud missile launchers and fuel depots using the effective AG-65 air-to-ground Maverick missile. The last aircraft of this type to see service in the Royal Navy was the GR9, which is still in service in the United States Marine Corps.

First coming into service in October 2006, it is an update of the GR7 and boasts advanced precision weaponry, new communications and airframe upgrades. The model at Fleet Air Arm Museum is the ZD433, which was delivered on 20 December 2011. Today it is affectionately known as 'Dirty Harry' and has been maintained in the same condition as when it served.

Above: *The inside of a Harrier II cockpit as it's about to take off from HMS Ark Royal in 2010*

"THE HARRIER'S UNIQUE DESIGN HAS MADE IT A DEADLY WAR MACHINE AND A GLOBAL ICON"

“AN ULTRA-EFFECTIVE AIR-TO-AIR MISSILE, THE SIDEWINDER IS RIGHT AT HOME WITH THE HARRIER’S ADVANCED TECHNOLOGY, UTILISING THE ONBOARD ACTIVE INFRARED GUIDANCE SYSTEM”

A Harrier GR9 in flight with a full payload of missiles

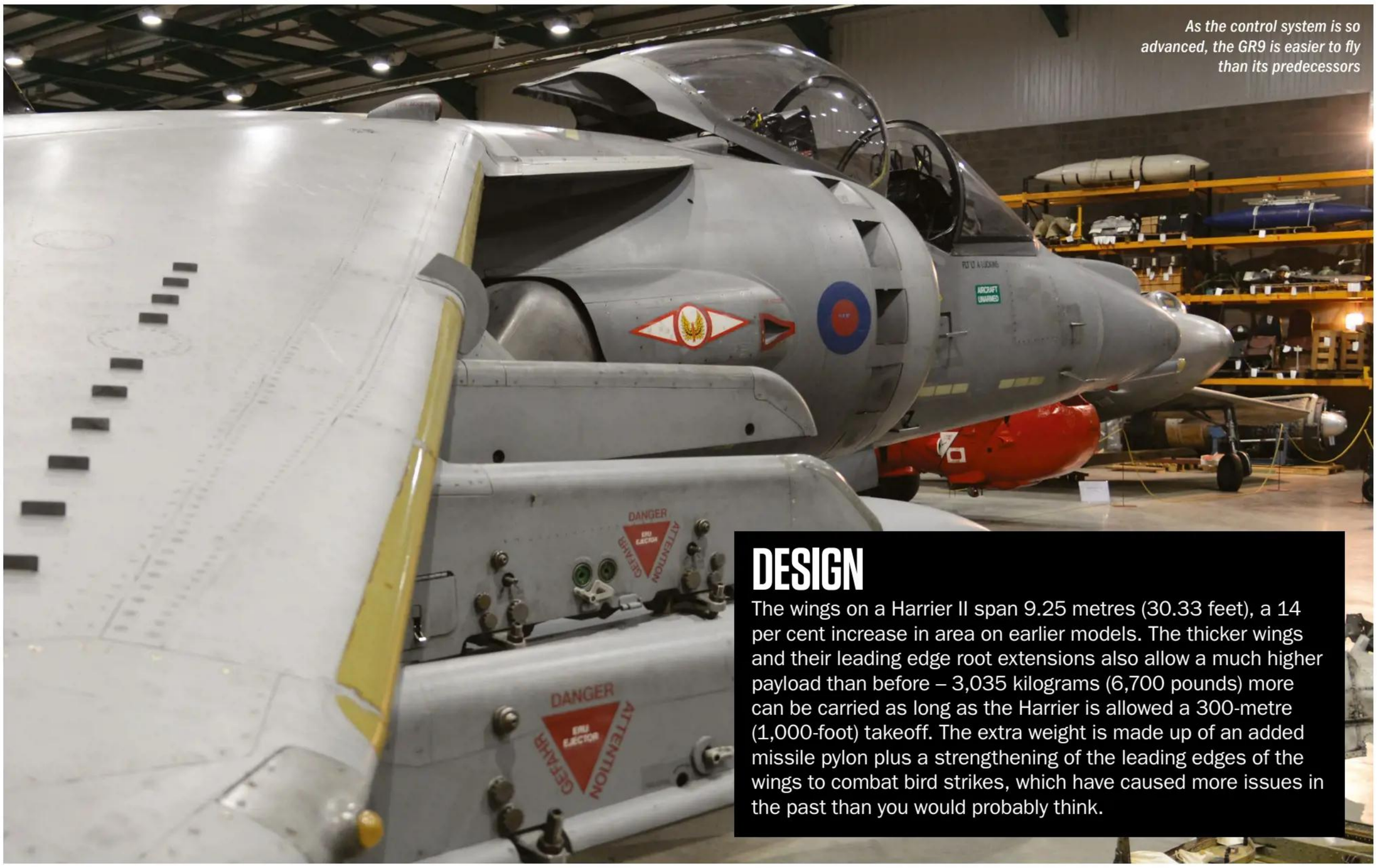
ARMAMENT

In 2004, BAE Systems was awarded a £100 million ($151 million) contract to develop the weapons on the GR9 to help it perform its attack duties. Taking inspiration from the Sea Harriers that served the British so admirably in the Falklands, the preferred weapon of the Harrier II is the supersonic heat-seeking AIM-9 Sidewinder. An ultra-effective air-to-air missile, the Sidewinder is right at home with the Harrier’s advanced technology, utilising the onboard active infrared guidance system.

Targets on the ground are also at risk from the GR9, as it comes equipped with Paveway or Maverick bombs that can destroy a large surface area or important objectives with blast, penetration and fragmentation. Unlike many attack aircraft, the GR9 is not armed with a machine gun but does incorporate a Brimstone anti-armour system and a pod of CR7 rockets.

The aircraft’s pod rockets next to the auxiliary fuel tank

The unguided pod rockets are a mainstay of the Harrier II’s armoury and are frequently used when missiles aren’t available



As the control system is so advanced, the GR9 is easier to fly than its predecessors

DESIGN

The wings on a Harrier II span 9.25 metres (30.33 feet), a 14 per cent increase in area on earlier models. The thicker wings and their leading edge root extensions also allow a much higher payload than before – 3,035 kilograms (6,700 pounds) more can be carried as long as the Harrier is allowed a 300-metre (1,000-foot) takeoff. The extra weight is made up of an added missile pylon plus a strengthening of the leading edges of the wings to combat bird strikes, which have caused more issues in the past than you would probably think.

The bubble canopy gives the pilot excellent 360-degree views so they can easily see if an enemy is on their six

COCKPIT

The GR9's cockpit is packed full of technology with a heads-up display (HUD), multipurpose colour displays (MPCDs) and an inertial navigation system (INS), all designed to aid the pilot on missions. Like the majority of fighter aircraft, many of the jet's features are controlled by a standard hands-on throttle and stick (HOTAS) lever. Night-vision goggles come as standard, and the aircraft also has a targeting pod that uses thermal imaging and a laser designator to identify hostiles on the ground when in difficult terrain or challenging weather conditions. The resulting image can even be ported via downlink to ground troops and vehicles to aid them on the same mission. Unlike in the UK, the US version of the GR9 is still up and running and future plans include installing a ground proximity warning system.

THE ORIGINAL HARRIER

THE REVOLUTION THAT WAS THE HAWKER SIDDELEY P.1127

In the 1950s, the idea of a fixed-wing aircraft that could achieve vertical takeoff was being investigated by the superpowers. Early prototypes like the American Lockheed XFV-1 fell by the wayside until the first Harrier came around in 1957 and changed everything. Only an experimental plane itself, it nevertheless led the way for a new breed of aircraft. Despite having critics early on (it was originally ridiculed for being a subsonic aircraft in the supersonic age), the first Harrier impressed with its innovative VSTOL (vertical and/or short take-off and landing) capabilities that were a precursor for the popular future VTOL (vertical take-off and landing) system in later versions of the craft. The hovering was achieved by thrust vectoring through rotating engine exhaust nozzles aimed at a 90-degree angle. It was powered by a Rolls-Royce 101 turbofan engine and was labelled as a single-seat close-support and reconnaissance fighter.

The prototype evolved into the British Harrier GR MK1, which entered service on 1 April 1969. It was later exported to the USA and renamed the AV-8A as it replaced the F-4 Phantom. It has had a series of updates since and the fighter is commonly remembered for its achievements in the Falklands War, when it downed 20 Argentine jets on 1,190 sorties with no air-to-air losses of its own.

The AV-8S Harrier, one of the later developments that spawned from the iconic Hawker Siddeley P.1127

Images: Wiki / PD / Gov

ROLLS ROYCE PEGASUS ENGINE

The GR9 is powered by a Rolls Royce Pegasus vectored-thrust turbofan engine. This model of the Harrier is fitted with a mk105 engine while the GR9A Harriers have the slightly upgraded mk107, which provides a huge 23,400lb of thrust. The mk107 is so powerful that in the rear fuselage section only metal able to withstand extremely high levels of fatigue can be used. The metal is usually a composite, which also helps with weight reduction to give the GR9 even more range. The materials used on this modern aircraft are a huge improvement on the aluminium alloy fuselage used on earlier models.

The Pegasus engine is specifically designed to allow for the Harrier's hovering capabilities. The secret is in rotating nozzles and airflow management

"THE MATERIALS USED ON THIS MODERN AIRCRAFT ARE A HUGE IMPROVEMENT ON THE ALUMINIUM ALLOY FUSELAGE"

The GR9 boasts an excellent aerodynamic design. The tailplane, for example, can be controlled to become more streamlined by hydraulic jacks

Our Senior Staff Writer Jack got a hands-on experience with the Harrier at Fleet Air Arm Museum

THE ROAD TO THE GR9

A CRASH COURSE ON THE OTHER MAJOR VARIANTS OF THE HARRIER II

GR5

The first model of the second-generation Harrier, the GR5 updated the avionics and armaments that were featured on the previous incarnation of the aircraft. An important step in the aircraft's evolution, a short-lived GR5A was also made before the next upgrade.

GR7

Next on the production line was the GR7, which had its maiden flight in May 1990. Now with night-time operational capabilities, the GR7 and GR7A had improved thrust and electrical systems and could carry a greater payload.

T10

Like many fighters, the second generation of the Harrier came with a training version. The T10 was based on the American trainer TAV-8B but, unlike its US equivalents, was combat ready.

"THE T10 WAS BASED ON THE AMERICAN TRAINER TAV-8B BUT, UNLIKE ITS US EQUIVALENTS, WAS COMBAT READY"

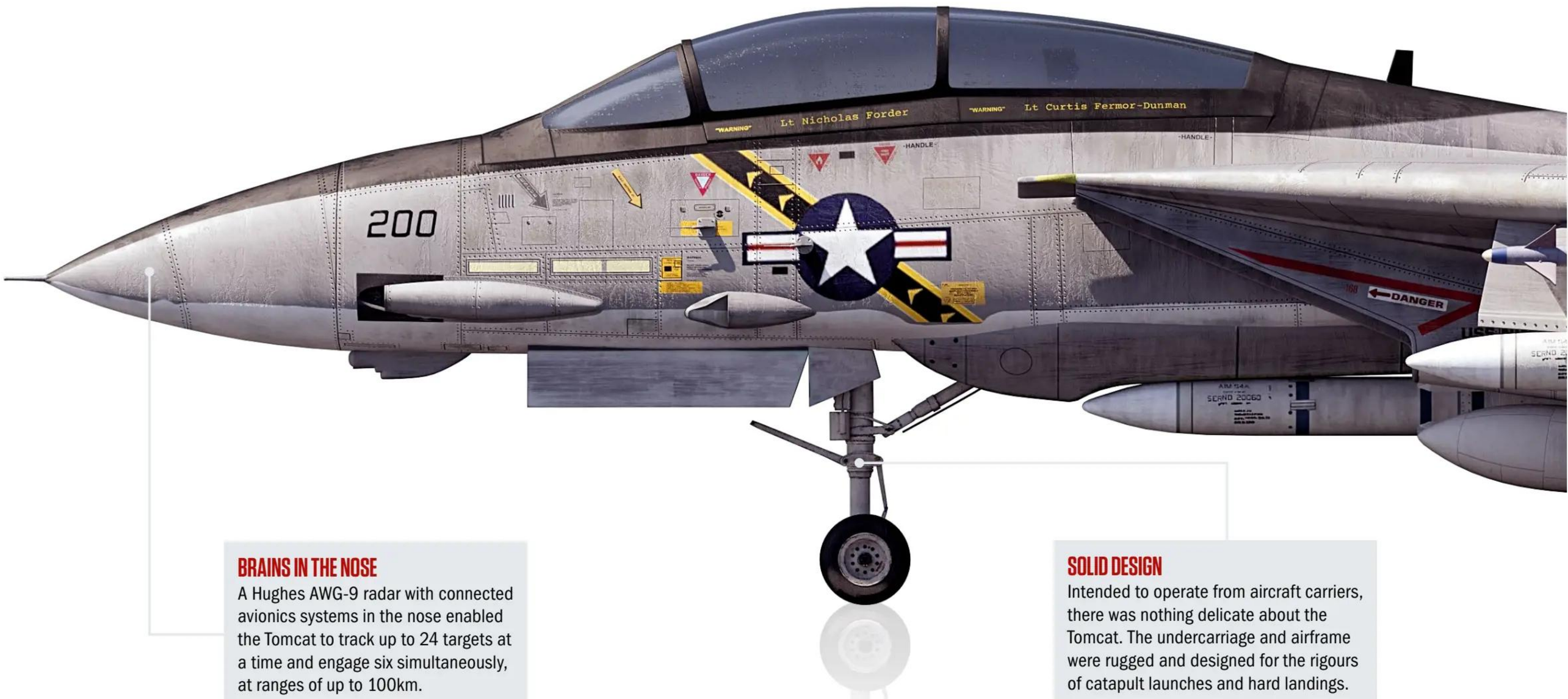
The design of the GR9 is based on lateral stability and ease of control

Images: Wiki / PD / Gov

GRUMMAN F-14D TOMCAT

WORDS **NEILL WATSON**

This United States Navy Cold War fighter was born from bitter experience over Vietnam



BRAINS IN THE NOSE

A Hughes AWG-9 radar with connected avionics systems in the nose enabled the Tomcat to track up to 24 targets at a time and engage six simultaneously, at ranges of up to 100km.

SOLID DESIGN

Intended to operate from aircraft carriers, there was nothing delicate about the Tomcat. The undercarriage and airframe were rugged and designed for the rigours of catapult launches and hard landings.

When design of the F-14 started in 1967, it was already clear that US airpower had taken a step backwards since the Korean War. US fighters over Vietnam were struggling for air superiority against a foe that was (on paper) far inferior. Recent focus had been on shooting missiles at Soviet nuclear bombers rather than engaging in air-to-air combat, and the US had lost the skills, experience and equipment needed to dogfight.

The F-14 was built to fill that gap. Primarily a long-range fleet defence interceptor, it was also an excellent air superiority fighter. The design could handle any fighter operations, with state-of-the-art radar, variable geometry wings, up to eight air-to-air missiles, and a 20mm cannon for good old-fashioned close-range dogfighting. Shooting to fame and glamour with the hit 1986 movie *Top Gun*, the Tomcat had substance as well as looks. It was the first line of defence of the US Navy through the Cold War, both Gulf Wars, and the fractious campaigns of the 1990s over both Iraq and the Balkans. Tomcats also saw distinguished service in the Islamic Republic of Iran Air Force during the Iran-Iraq War of 1980-88.

Feeling the need for speed: an F-14 going supersonic

GRUMMAN F-14D TOMCAT

COMMISSIONED:	1969
ORIGIN:	USA
LENGTH:	19.13M
WINGSPAN:	19.5M
ENGINE:	2 X GENERAL ELECTRIC F110-GE-400 73.9 KN (16,610LBF) AFTER-BURNING TURBOFANS
CREW:	2
PRIMARY WEAPON:	UP TO 8 AIR-TO-AIR MISSILES & 1 X 20MM VULCAN CANNON
SECONDARY WEAPON:	NON-GUIDED AND GUIDED BOMBS

Illustration: Nicholas Forder

***Left:** Fighter Squadron 14 (VF-14) F-14A Tomcat aircraft fly over the French aircraft carrier FOCH (R 99) during a joint exercise*

TWIN-TAILED CAT

The Tomcat needed a large vertical fin area for the best performance. Twin tails enabled the same surface area on shorter structures, enabling easier stowage aboard cramped aircraft carrier hangers.

BROAD NACELLES

The widely spaced engine nacelles bracketed a storage area for the fuel, avionics and weapons pylons usually carried in the wings of aircraft but unable to fit in the Tomcat's swing-wings.

"THE DESIGN COULD HANDLE ANY FIGHTER OPERATIONS, WITH STATE OF THE ART RADAR, VARIABLE GEOMETRY WINGS, UP TO EIGHT AIR-TO-AIR MISSILES, AND ALSO A 20MM CANNON FOR GOOD OLD-FASHIONED CLOSE-RANGE DOGFIGHTING"

An F-14 Tomcat coming in to land on the USS Nimitz

All images © Alamy

Loading the Tomcat's Vulcan cannon

Tomcat test-firing an AIM-54 Phoenix missile

ARMAMENT

The Tomcat had fearsome claws with up to eight air-to-air missiles – half were carried under the fuselage between the engine nacelles and the rest under the wing roots. A mix of AIM-7 Sparrow medium-range semi-active radar-homing, AIM-9 Sidewinder short-range heat-seeking and AIM-54 Phoenix long-range hypersonic missiles gave the pilot a broad spectrum of options. For close-in work, a single 20mm M61A-1 Vulcan six-barrelled rotary cannon with 675 rounds was fitted. In the 1990s, the F-14D was upgraded to also use a range of precision and non-guided bombs.

"THE ENGINES COULD PROVIDE SUFFICIENT THRUST TO LAUNCH THE TOMCAT FROM AN AIRCRAFT CARRIER WITHOUT NEEDING AFTERBURNERS"

ENGINE

The early Tomcat F-14As were fitted with Pratt & Whitney TF30 turbofan 93kN (20,900lbf) engines, but a series of reliability issues led to their replacement in the 1980s by General Electric F110-GE-400 turbofans, capable of 73.9kN (16,610lbf) thrust or up to 125kN (28,200lbf) on afterburner. They could provide sufficient thrust to launch the Tomcat from an aircraft carrier without needing afterburners, and push it up to 53,000ft (16,000m) and Mach 2.34. A computerised fuel control system and adjustable air intake and exhaust nozzles optimised performance at all speeds.

An F-14 climbs on full afterburner

The widely spaced engines allowed avionics, fuel and airbrakes to be positioned between them

An F-14 with its wings forward in loiter mode

An F-14 with a full load of eight air-to-air missiles

DESIGN

Constructed of steel, titanium and composites, the broad airframe of the Tomcat provided between 40 and 60 per cent of the lift generated by the design, depending on wing position. The variable geometry wings automatically adjusted to improve flight dynamics in different situations: fully extended to a 20-degree angle for take-off or landing, or loitering on patrol; drawn back to 68-degree for supersonic flight (or further back still for storage). The swept wings complicated the flight controls, but the twin-tails gave improved stability.

© Alamy

An Islamic Republic of Iran Air Force F-14A Tomcat, in flight in 2018

SERVICE HISTORY

After a first flight in 1970, the F-14 entered frontline service with the US Navy in 1974. By 1983 it was the USN's primary fleet defence fighter and had already proven its worth. In August 1981, two F-14s were engaged by two Libyan Sukhoi Su-22s. The F-14s evaded the attack and retaliated by shooting down both Su-22s. Tomcats would see active service in the Mediterranean, the Persian Gulf, Afghanistan and over the Balkans. The type achieved multiple successes in air-to-air and later an air-to-ground role, with only a single aircraft being lost to enemy action. It was withdrawn from US service in 2006.

The Tomcat also saw extensive combat during the Iran-Iraq War (1980-88) – the Shah of Iran had received 79 Tomcats before the Iranian Revolution of 1979. Tomcats achieved an excellent kill-to-loss ratio in the subsequent war with Iraq and, despite being starved of spare parts, small numbers remain in Iranian service today.

An F-14 on USS George Washington

© Alamy

"THE TYPE ACHIEVED MULTIPLE SUCCESSES IN AIR-TO-AIR AND LATER AN AIR-TO-GROUND ROLE, WITH ONLY A SINGLE AIRCRAFT BEING LOST TO ENEMY ACTION"

The crew sat high with a good all-round view

© Alamy

***Left:** The weapons officer's view; numerous mirrors helped them keep lookout to the rear*

***Above:** The crew used a hybrid of digital and analogue controls and displays*

COCKPIT

The Tomcat boasted a tandem cockpit for the two crew, with pilot in front and weapons officer behind. The bubble cockpit allowed both crew members good views for close air combat. Only the pilot had flight controls, but both enjoyed a hybrid of digital and analogue controls and displays. A heads-up display gave the pilot essential flight information in their forward field of view. An electro-optical system automatically searched for and locked onto targets, displaying them on a small video screen.

BLACKBURN B

Above: The Buccaneer was typically active in the North Sea area during its service

WORDS & IMAGES **NEILL WATSON**

With a distinguished career spanning several decades, the Buccaneer was one of the RAF's most effective strike jets

Originally designed as a low-level strike and reconnaissance aircraft for carrier-borne operations, the Blackburn Buccaneer served on aircraft carriers with Britain's Fleet Air Arm for several years and was pressed into service with the Royal Air Force after the controversial cancellation of the TSR2 project.

The Buccaneer had a long service career, participating in all of the conflicts that British armed forces have been involved in until its retirement in 1994. At its high point, more than 100 Buccaneers served in the RAF. The aircraft was also supplied to the South African Air Force, where it was used for close air support in the Border Wars with Angola.

Following World War II, the Royal Navy became worried at the rapid expansion of the Soviet navy. The Russian introduction of very fast battle cruisers of similar design to the German pocket battleships of World War II was of great concern, as these new Soviet battleships were fast, highly manoeuvrable and would be a huge threat to Atlantic shipping in the event of an armed conflict. Rather than try to match the capability with expensive ship-building, in 1952 the decision was taken to design a fast, low-level strike aircraft capable of operating from aircraft carriers and delivering a large, sometimes nuclear, payload to strike against the Soviet navy.

The piping for the bleed-air system can be seen when the Buccaneer's wings are folded

BLACKBURN BUCCANEER S2

LENGTH:	63FT 5IN (19.33M)
WINGSPAN:	44FT (13.41M)
HEIGHT:	16FT 3IN (4.97M)
ENGINE:	2 × ROLLS-ROYCE SPEY MK 101 TURBOFANS, 11,100LBF (49KN) EACH
CREW:	2 (PILOT AND OBSERVER)
MAX SPEED:	645MPH (560KN, 1,074KM/H) AT 200FT (60M)
RANGE:	2,300MI (2,000NMI, 3,700KM)
HARDPOINTS:	4 × UNDER-WING PYLON STATIONS, 1× INTERNAL ROTATING BOMB BAY WITH A CAPACITY OF 12,000LB (5,443KG) AND PROVISIONS TO CARRY COMBINATIONS OF:
ROCKETS:	4 × MATRA ROCKET PODS WITH 18 × SNEB 68MM ROCKETS EACH
MISSILES:	2 × AIM-9 SIDEWINDERS FOR SELF-DEFENCE OR 2 × AS-37 MARTEL MISSILES OR 4 × SEA EAGLE MISSILES
BOMBS:	VARIOUS UNGUIDED BOMBS, LASER-GUIDED BOMBS, AS WELL AS THE RED BEARD OR WE.177 TACTICAL NUCLEAR BOMBS

BUCCANEER S2

"AT ITS HIGH POINT, MORE THAN 100 BUCCANEERS SERVED IN THE ROYAL AIR FORCE"

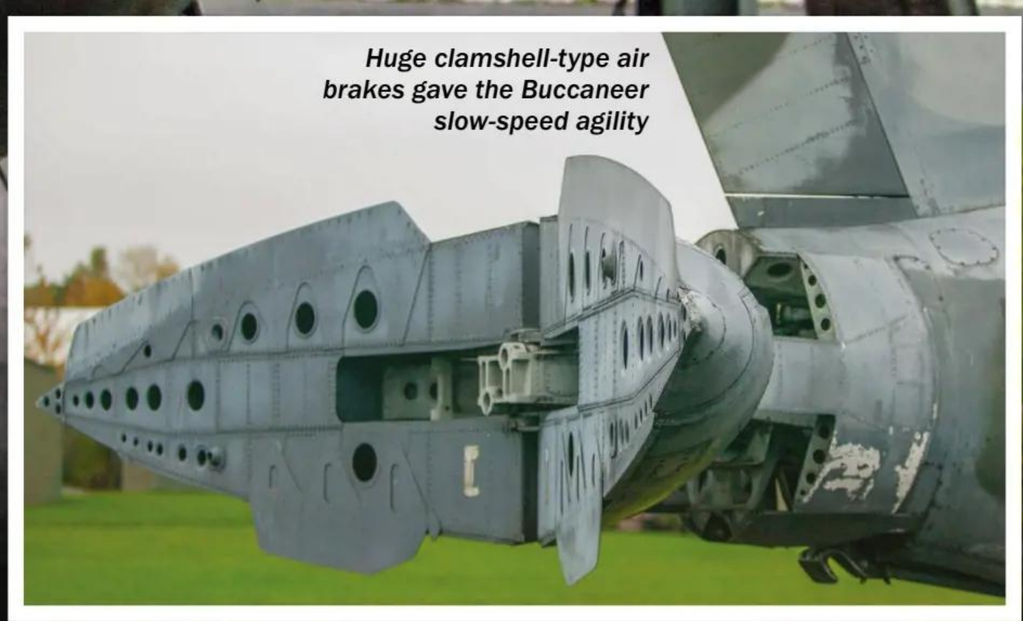
© Alamy

The Buccaneer was built to take off in the arduous maritime environment

Folding wings were part of the original Fleet Air Arm requirement

Image: Wiki / PD /Gov

Extensive modifications to the air intakes were needed for the Rolls Royce Spey engines in the S2 variant



Huge clamshell-type air brakes gave the Buccaneer slow-speed agility

DESIGN

The requirement was for a fast, jet-powered attack aircraft capable of flying slow enough to land on an aircraft carrier but also fast enough and with enough payload to fight against Soviet military shipping. This was a difficult task, as in 1952, jet technology was in its infancy.

Blackburn Aircraft won the contract with the Buccaneer S1, introduced in 1963. Its design had folding wings for storage on board, an arrestor hook for landings, plus a huge tail-mounted air brake to aid handling at low speeds. In addition, the Buccaneer employed an aerodynamic technique known as 'flap blowing'. Bleed air was taken from the jet engines and blown over areas of the wings and flight-control surfaces to improve lift and enable the aircraft to respond better at low speeds. The piping for the bleed-air system can be seen inside of the wing structure when the aircraft has the wings folded. At the time, this technique, called Boundary Layer, was at the cutting edge of aerodynamics.

The initial S1 was underpowered, and while the aircraft had a good payload, an engine failure while at low speed landing or taking off from a carrier was disastrous. To solve the issue, the S2 was developed with more powerful Rolls Royce Spey engines. This aircraft had 40 per cent more power and significantly better fuel economy and went on to be highly successful until retirement in 1994.

The Buccaneer also featured an all-weather capability, something that was rare at the time. Early generation electronic flight systems controls, coupled with nose-mounted on-board radar, gave the aircraft the capability to fly at very low levels and high speeds in bad weather.

POWERPLANT

The S1 Buccaneer was powered by the early generation De Havilland Gyron turbojet engine, delivering 7,100 pounds of thrust. With this power, the aircraft could not lift a full fuel tank as well as a full weapon load. In order to operate from aircraft carriers, the S1 had to take off with minimum fuel and then rendezvous with an in-flight refuelling aircraft to take on full fuel. Clearly, this was an inefficient system that had to be rectified.

The S2 was a modified Buccaneer with the Rolls Royce Spey engine, significantly more powerful and giving the aircraft far greater versatility. The new engines required some modifications to the aircraft structure including the air intakes, but proved to be highly successful.

The back-seat crewman was responsible for weapons systems and navigation and had a separate windscreen in the event of canopy jettison

ARMAMENT

Originally designed to deliver a nuclear weapon at Soviet warships, the diversity of the Buccaneer payloads over the years is symptomatic of the political attitude towards military spending of the time. The original weapon in the design was to be the 'Green Cheese' air-launched nuclear missile. However, the development programme for the missile was cancelled, meaning that the Buccaneer first flew with the unguided 20-kiloton Red Beard bomb.

The aircraft had a fully concealed bomb bay to give it a high cruise speed at low level. This meant that special rotating bomb bay doors were designed to open up to the maximum speed of the aircraft at 0.9 mach. The large weapons bay could also carry a range of other payloads, including conventional non-nuclear bombs. At the time it joined the Royal Navy, it could carry any payload that the navy had available. Early in its career, the Buccaneer carried conventional bombs against shipping, but this was considered hazardous, as the low-level capability had to be sacrificed to climb and deliver the bombs. Eventually, the aircraft were upgraded to carry the stand-off capability Sea Eagle missile.

Buccaneers could also carry a photo-reconnaissance pod, plus a large ferry tank for positioning flights across the globe. Under-wing hardpoints could carry weapons. Laser designator systems extended the life of the aircraft, which often flew alongside the newer Tornado in support.

"SPECIAL ROTATING BOMB BAY DOORS WERE DESIGNED TO OPEN UP TO THE MAXIMUM SPEED OF THE AIRCRAFT AT 0.9 MACH"

The original Buccaneer was designed for nuclear weapons delivery

A test shot of a Red Beard bomb, the first British tactical nuclear weapon

Images: Neill Watson, Wiki / PD / Gov

Both crew members sat on early-generation Martin Baker ejection seats. Early jet era instrumentation could be haphazard in layout

COCKPIT

The crew of two flew in a tandem cockpit configuration, seated in early-generation Martin Baker ejection seats. The combination of early-generation electronic weapons technology and mechanical flight instruments made the cockpit layout a little haphazard at first glance. No modern heads-up displays were available at this time, meaning the pilot had to look inside for all instrument displays.

The rear-seat crew member operated the weapons and, later, electronic countermeasures, plus the nose-mounted radar and weapons-control systems. A large single-piece canopy covered the crew. This could be jettisoned in the event of ejection, with the rear-seat crewman having an additional windscreen for protection against the high-speed air blast.

Below, left to right:
The pilot's joystick operated hydraulically boosted flying surfaces

Early jet cockpits had no heads-up display. The second airspeed indicator aided carrier landings

Cold War jet cockpits were designed for functionality above all else

In the first Gulf War, Buccaneers were repainted and re-equipped in just 72 hours for a desert warfare role

ROLES AND DIVERSITY

While the Buccaneer was effective in its original role as a fast maritime strike aircraft, it is perhaps best known as a Royal Air Force jet. Blackburn originally proposed the aircraft to the RAF as a replacement to the Canberra. The RAF insisted that their new jet had to be supersonic, so the Buccaneer was discounted. However, at this time, in the mid 1960s, there was much political upheaval in the procurement of military equipment, with spending cuts, inter-force distrust and rivalry as the British army, navy and air force each fought to defend their budgets and capability.

With the controversial cancellation of the TSR2 project, the Blackburn offer was revisited. Additionally, the contentious 1957 White Paper on Defence spending called for the retirement of Navy aircraft carriers, with the RAF tasked with assuming the capability of striking against maritime targets.

While the RAF may have been reluctant to take the Buccaneer, it proved to be a very useful asset. As the Panavia Tornado programme was delayed, it continued to serve a useful role. Even after the introduction of the Tornado, it continued to fly missions. Probably the most famous was the rapid deployment at short notice in the 1991 Gulf War. Re-equipped and repainted in desert camouflage in less than 72 hours, the Buccaneers flew with laser designation guidance systems. Flying alongside two Tornados, the Buccaneer used the laser to 'designate' the target for the smart bomb that was then delivered by the Tornado.

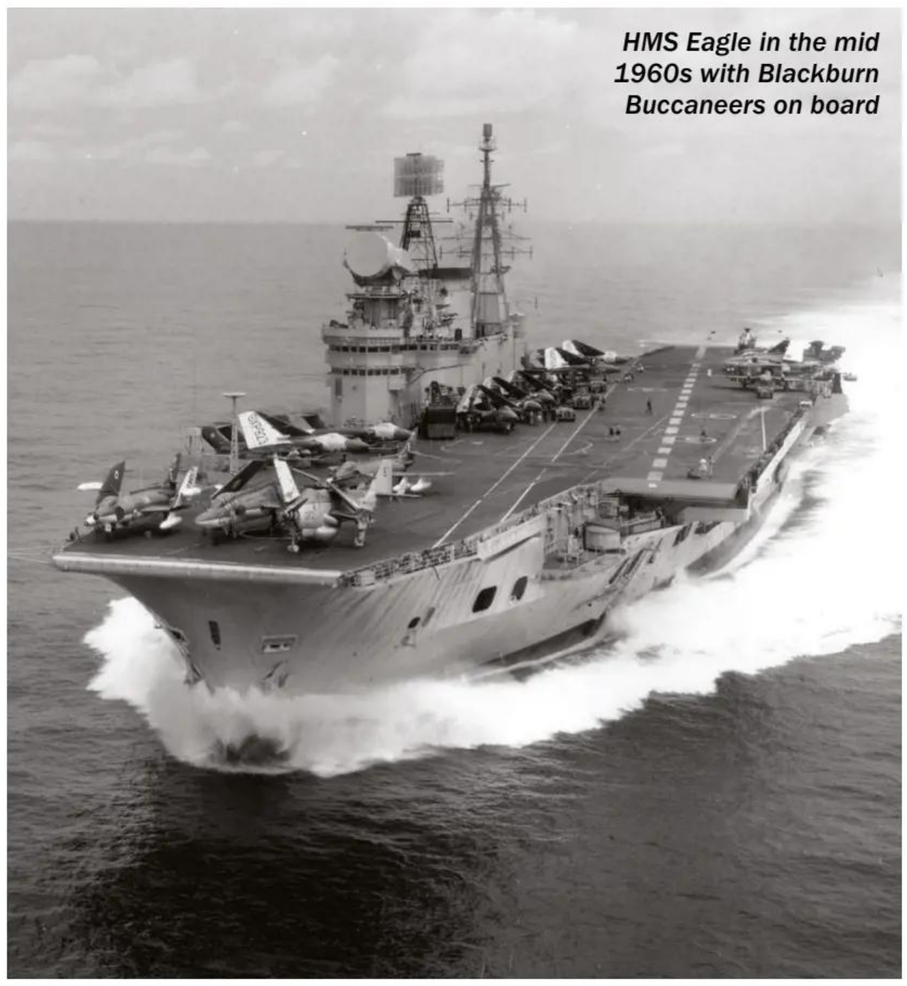
This teamwork delivered a huge amount of damage to bridges and other infrastructure. Additionally, Buccaneers delivered their own weapons, one such mission managing to hit two Iraqi aircraft while still taxiing on the ground.

Despite the introduction of more modern aircraft alongside it, including the Harrier and the Jaguar, the Buccaneer continued to play a very cost-effective and useful role amid the constantly changing political backdrop of the 1957 White Paper, the end of the Cold War and the subsequent 1991 Gulf War.

TECH STATS

The particular aircraft in these photographs is XN974, the very first production S2 Buccaneer. This aircraft was sent to the Royal Aeronautical Establishment for trials and testing, and then on to HMS Eagle for sea trials. It then flew to the USA, where it was used in Nevada for hot-weather testing.

XN974 was used continually throughout its life as a development test bed. As the political and military climate changed, weapons systems were introduced and new electric warfare systems designed, this aircraft was used for testing the systems before they went live with frontline squadrons. It is preserved in ground running condition at Yorkshire Air Museum, where it is often seen taxiing on the runways at events.



HMS Eagle in the mid 1960s with Blackburn Buccaneers on board

Images: Neill Watson, Wiki / PD / Gov

PANAVIA TORNADO

Above: *The three sections of the Panavia roundel represent the colours of the British, German and Italian flags*

Europe's multi-role workhorse has stood the test of time to serve in more than five decades of combat

WORDS & IMAGES **NEILL WATSON**

At the end of World War II, early-generation jet technology was incorporated into stunning new designs, as jets including the AVRO Vulcan, Gloster Meteor and American Lockheed T-33 replaced piston-engined aircraft. This early generation of jet engine technology was advancing at a very high rate. Together with advances in aerodynamic features including swept wings, plus the growing threat from Russia, these early jets were soon out of date. Several nations realised the next generation of fast jet was going to be extremely expensive to develop.

During the 1960s, the UK's Royal Air Force, together with other global air forces, began to look to the future and their requirements for fast jet warfare. The RAF's Buccaneer and AVRO Vulcan would eventually need to be replaced. Britain, having controversially cancelled the pioneering TSR-2 project and rejected the American F-111 as unsuitable, continued to search for a solution. Germany, Italy, the Netherlands, Canada and Belgium all needed to find a replacement for the ageing, early-generation F-104 Starfighter.

"COMPANIES FROM BRITAIN, GERMANY, ITALY AND THE NETHERLANDS FORMED A JOINT COMPANY CALLED PANAVIA TO DEVELOP AND MANUFACTURE THE NEW JET"

***Right:** The Tornado's versatile external weapon carrying ability gave it true multi-role capability*

A crew of two and supersonic capability made the Tornado a superb weapons platform

PANAVIA TORNADO

LENGTH:	16.72M (54FT 10IN)
WINGSPAN:	13.91M (45.6FT) AT 25° WING SWEEP, 8.6M (28.2FT) AT 67° WING SWEEP
HEIGHT:	5.95M (19.5FT)
WING AREA:	26.6M² (286FT²)
LOADED WEIGHT:	20,240KG (44,620LB)
ENGINE:	2 X TURBO-UNION RB199-34R MK 103 AFTERBURNING TURBOFANS
CREW:	2
MAX SPEED:	MACH 2.2 (2,400KM/H, 1,490 MPH) AT 9,000M (30,000FT)
RANGE:	1,390KM (870MI)

Images: Neill Watson, Wiki / PD / Gov

DESIGN

Each nation had a pressing need to replace old airframes, but all had diverse requirements, so the decision was taken to jointly develop a multi-role aircraft capable of being adapted for use across several capabilities ranging from low-level ground attack to high-altitude precision bombing, and also as an interceptor/fighter. Canada withdrew for political reasons, as it was felt that the aircraft manufacturing would all be undertaken in Europe, while Belgium chose the French Mirage 5.

In 1968, the project was given the name MRCA (Multi Role Combat Aircraft), and the following year aerospace companies from Britain, Germany, Italy and the Netherlands formed a joint company called Panavia to develop and manufacture the new jet.

Variable geometry wing technology was employed for the first time in a European project. The design enabled the wing to be swept forwards by the pilot to give low-speed lift and manoeuvrability for landing, but swept back for high-speed flight. The concept was invented at the end of WWII by Sir Barnes Wallis, the creator of the Dambusters' 'bouncing bomb', but no British aircraft manufacturer at the time employed it. The American F-111 flew with a variable wing first, with the Tornado subsequently using what was known as the 'swing wing' technology to fulfil its diverse requirements.

In 1971, the respective governments signed an agreement to develop a final design – a two-seat, twin-engined aircraft with switchable external payloads that could fly at very low level in poor weather and penetrate enemy defences to deliver a variable payload. Britain also wanted an interceptor version of the aircraft, which was subsequently introduced as the F2 and F3 with a longer nose section.

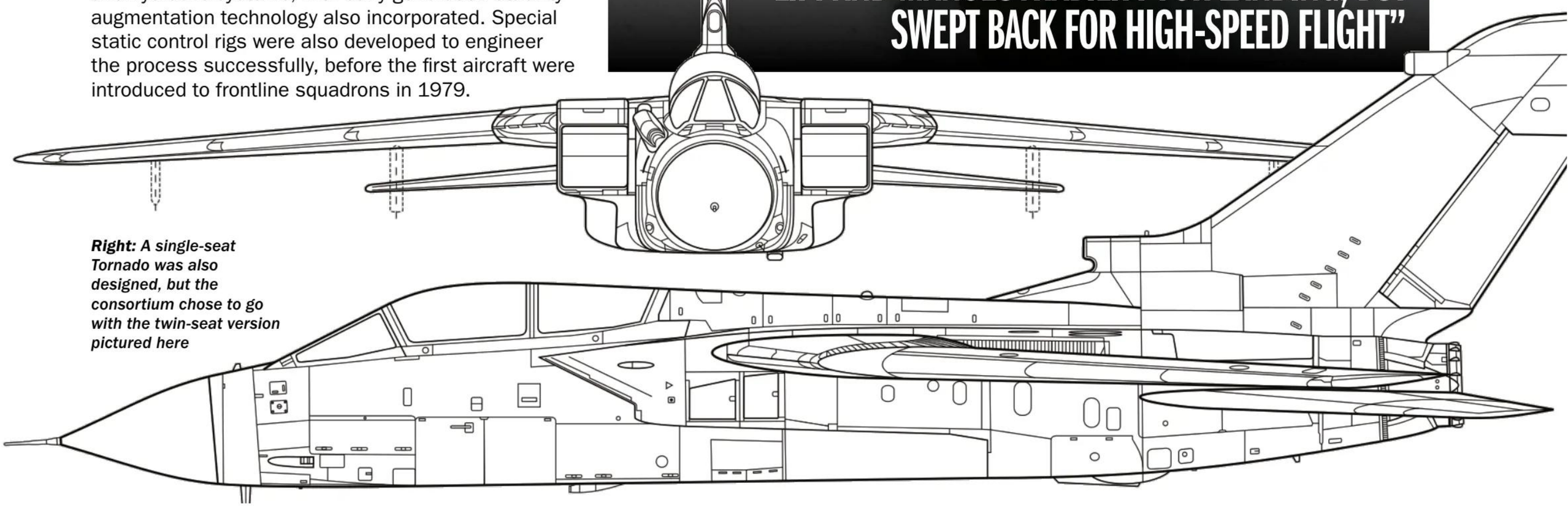
The first aircraft flew in August 1974, with development aircraft flying in 1976. The Tornado was an extremely difficult aircraft to produce from a basic design through to a final fighting aircraft due to the hugely changeable nature of the payload requirements and the variable wing technology. The aircraft had no internal bomb bay, as WWII bombers had, with all weapons and other payloads carried externally under the wings and fuselage.

As the wing swept back for high-speed flight, whatever weapons or external fuel tanks were fitted had to remain aligned with the centreline of the aircraft, plus as the wing moved back, it shifted the whole centre of gravity of the aircraft. Flight controls at that time were a mixture of electro-mechanical and hydraulic systems, with early-generation stability augmentation technology also incorporated. Special static control rigs were also developed to engineer the process successfully, before the first aircraft were introduced to frontline squadrons in 1979.

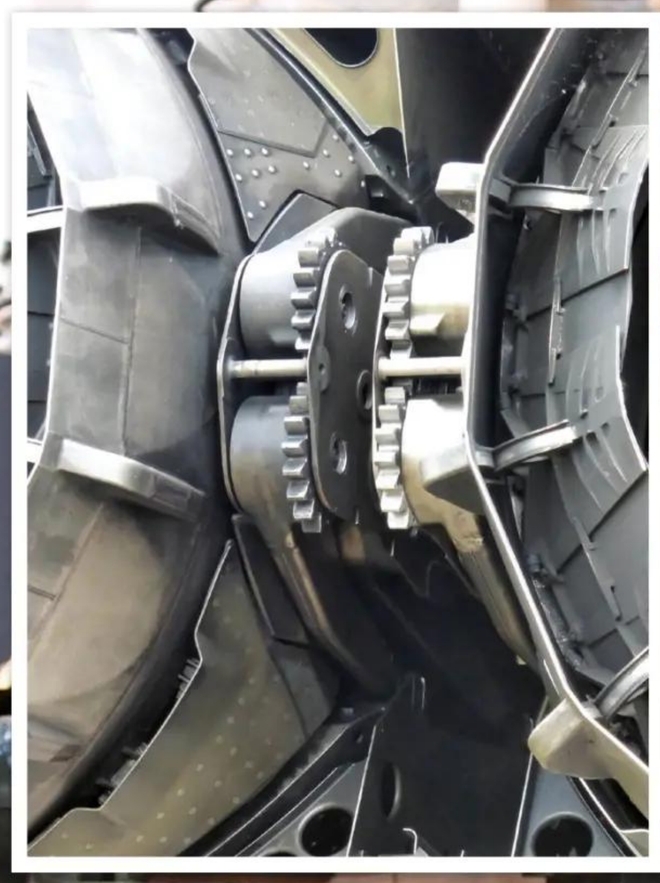
Afterburning jets developed by Rolls-Royce gave supersonic performance

Variable wing geometry was complex but gave good handling characteristics across wide speed ranges

"THE DESIGN ENABLED THE WING TO BE SWEPT FORWARDS BY THE PILOT TO GIVE LOW-SPEED LIFT AND MANOEUVRABILITY FOR LANDING, BUT SWEPT BACK FOR HIGH-SPEED FLIGHT"



***Right:** A single-seat Tornado was also designed, but the consortium chose to go with the twin-seat version pictured here*



Developed by Rolls Royce, the twin engines proved reliable and easy to service

***Inset above:** Afterburning engines inject fuel into the exhaust gasses*

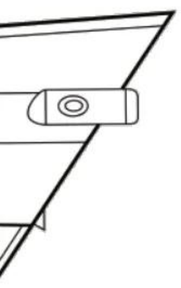
POWERPLANT

Rolls Royce designed the RB199 engine specifically for the Panavia Tornado. Using technology and skills learned during the Corncorde airliner development, the new engine was test flown in a special pod beneath a test Vulcan bomber, in the same way that the Olympus engine had been for Concorde. The final engine design was manufactured in the same way as the aircraft – in a joint consortium of engine companies called Turbo Union that was made up of Rolls Royce, Germany's MTU and Italy's FIAT Avio.

The engines employed a modular construction, which enabled in-service switching of engine modules without changing the entire engine. This gave improved efficiency, enabling aircraft to be quickly returned to service after receiving any damage.

Tornado aircraft flew with two RB199 engines, with at-the-time very advanced digital controls to reduce pilot workload. The engines had afterburner capability, where fuel is ignited into the exhaust system to give a massive increase in power for short periods. The engines also incorporated reverse thrust for improved braking performance when landing.

"THE ENGINES HAD AFTERBURNER CAPABILITY, WHERE FUEL IS IGNITED INTO THE EXHAUST SYSTEM TO GIVE A MASSIVE INCREASE IN POWER FOR SHORT PERIODS"



ARMAMENT

The very nature of its original design philosophy meant that Tornados across the different air forces carried remarkably diverse payloads. Under the main fuselage there were four light-duty and three heavy-duty 'hard points' for mounting weapons. Another four under-wing mounting points could carry 9,000 kilograms of bombs and other stores, ranging from long-range ferry tanks, short-range tactical fuel tanks that could be used supersonically, to air-to-ground and air-to-air missiles. Originally Two Mauser cannons were also mounted on the starboard side of the fuselage but one was removed in later variants.

A Tornado could carry any combination of AIM Sidewinder, ASRAAM, Maverick, Brimstone or even ALARM anti-radiation missiles for targeting insurgents using electronic devices. Bombs it could carry included Paveway, BL755 cluster bombs or even tactical nuclear weapons.

Additional uses for the mounting points included long-range fuel tanks plus external avionics pods including Rafael listening pods, laser targeting and Sky Shadow electronic countermeasures and jamming equipment.

The under-wing stores had to work in conjunction with the variable wing technology, but offered excellent versatility

Images: Neill Watson, Wiki / PD / Gov

***Right:** The pilot looked through a Head-Up Display (HUD)*

“THE COCKPIT WAS SPACIOUS, WITH ROOM ON THE MAIN INSTRUMENT PANEL AND SIDE PANELS FOR THE COMPLEX AVIONICS SYSTEMS”

The back seat crew member was responsible for tactics, navigation and weapons selection

COCKPIT

A crew of two both sat on Martin Baker Mk10 ejection seats. The seats were remarkably advanced and included integral personal equipment connectors for anti-G suits, oxygen supply, communications and air conditioning. The ejection seats had what is known as ‘zero zero’ capability, meaning that a trapped crew could escape from zero speed and zero height, all the way to 50,000 feet and 630 knots. The cockpit was spacious, with room on the main instrument panel and side panels for the complex avionics systems.

The pilot looked forwards through a heads-up display, which projected vital flight information onto the windscreen, meaning that they never needed to re-focus their view inside during combat. The rear seat crew member was responsible for the operation of the diverse weapons stores, assessing targets and threats, and also operated the advanced radar system housed in the nose behind the carbon composite cone.

Cockpit systems were upgraded several times across the life of the aircraft

"ITS VITAL ROLES IN VARIOUS CONFLICTS THROUGHOUT THE DECADES HAVE PROVED WHAT A SUPERB AIRCRAFT IT TURNED OUT TO BE"

Tornados were repainted in a low-visibility grey towards the end of the lifespan

IN SERVICE

Tornado aircraft have been operated by the Royal Air Force, Luftwaffe and Italian Air Forces throughout the life of the aircraft. Saudi Arabia also bought almost 100 Tornados to operate in the Middle East.

At several times throughout its life, the Tornado was scheduled for replacement. However, its vital roles in various conflicts throughout the decades have proved what a superb aircraft it turned out to be. Due to a combination of the aircraft's successes, its affectionate reception from flight crews, plus cost overruns and delays for replacements, Tornados have received an array of mid-life upgrades to ensure that some remain active today. In the 1990s, the Royal Air Force upgraded many of the original GR1 designated aircraft to GR4 specification.

The upgrades principally improved the aircraft's weapons and flight technologies. As digital systems advanced and GPS became the standard for positioning fixes, the aircraft were upgraded to the latest radar, flight and navigation systems. Even as late as 2005, Germany undertook further software and technology upgrades that enable Tornado aircraft to exchange tactical and radar information with other friendly aircraft while in combat.

The aircraft you see in these pictures was the pioneer aircraft for the GR4 upgrade programme. This aircraft was used to test and develop all of the new systems and software advances that were subsequently incorporated into frontline GR4 Tornados and is preserved by the Yorkshire Air Museum.

Despite being designed in the 1960s and of an age that may make other aircraft of the time suitable for museum display, the GR4 Tornado continued to fight as a frontline aircraft in 2015. The latest Eurofighter Typhoon still does not have the full capability for ground attack and support for ground forces that the GR4 is capable of. The GR4 has served in all of the recent and, indeed, current conflicts that require close support of ground forces and precision bombing capability against insurgents.

The main air forces that flew the Tornado are slowly phasing out the aircraft, but the process is proving to be an extended one. One of the reasons why the Tornado continues to be a vital aircraft is probably due to the original Cold War design. In a world where threats to nations take many different forms and require diverse capabilities of armed forces tasked with dealing with them, the Multi Role Combat Aircraft, as it was originally called in 1964, has proved to be very multi-role indeed.

Operated by several European air forces, plus Saudi Arabia, NATO exercises were often celebrated with unique colour schemes

Images: Neill Watson, Wiki / PD / Gov

F-15 EAGLE

This American twin-engine plane is one of the most successful modern fighters

TWO ENGINES
The two Pratt & Whitney F100-PW-100, 200 or 229 turbofan engines with afterburners were originally asked for as it was believed that twin engines would be able to respond to throttle changes more rapidly.

AVIONICS SYSTEM
The cockpit of an F-15 houses a miltimission avionics system, which includes advanced radar and a system that can identify friend and foe.

"THE PLANE IS A FIRM FAVOURITE THANKS TO ITS ABILITY TO DETECT, ACQUIRE, TRACK AND ATTACK ENEMY AIRCRAFT"

In 1972, the F-15A took to the air for the first time. It was the prototype for what would become a flagship fighting plane for the US Air Force just two years later, when the first F-15 Eagle was delivered in November 1974. The Eagle officially became a part of the US Air Force 14 months later.

The F-15 has been a major part of American military operations. The C, D and E models saw a lot of use in the Gulf War – most notably, Operations Desert Shield and Desert Storm in 1990. During the entirety of the conflict, McDonnell Douglass – the designers of the F-15 – could boast that their fighter jet had won 36 of the United States' 39 air-to-air victories against Iraqi forces.

It wasn't just the US that recognised the F-15 as a powerful and useful fighter. Japan's Air Self-Defense Force has 200 Mitsubishi F-15Js, and the Royal Saudi Air Force had 211 F-15s in its ranks at the last count in 2022. The Israeli Air Force is another fan, having used F-15s since 1977 and having 84 in service as of 2022. In fact, it was Israeli Air Face ace Mishe Melnik who scored the first confirmed kill by an F-15 in 1979 during Israeli raids against Palestinian factions in Lebanon.

McDonnell Douglass has brought out several new models of the F-15 over the years: the single-seat C and two-seat D models were brought into the US Air Force in 1979. The plane is a firm favourite thanks to its ability to detect, acquire, track and attack enemy aircraft, and its design allows one person to safely and effectively perform air-to-air combat.

The F-15 is a highly maneuvarible plane thanks to its high engine thrust-to-weight ratio and low wing loading, and a multimission avionics system that most other fighter aircraft don't have.

© Getty

***Left:** An F-15 Eagle is pictured here, flying through a storm*

***Inset below:** The F-15 Eagle has become an iconic fighter plane*

WEAPONRY

An F-15 gives the military a choice of weaponry; there's one internally mounted six-barrel cannon, and up to eight AMRAAMs can be carried externally.

© Alamy

***Below:** This F-15 Eagle is flying in the Mach Loop valleys in Wales*

© Alamy

F-15 EAGLE

COMMISSIONED:	1972
ORIGIN:	USA
LENGTH:	19.43M (63FT 9IN)
WINGSPAN:	13.06M (42FT 10IN)
RANGE:	5,552KM (3,450M)
ENGINE:	2 X PRATT & WHITNEY F100-PW-100, 220 OR 229 TURBOFAN ENGINES WITH AFTERBURNERS
CREW:	1
WEAPONS:	1 X 0.787IN (20MM) M61A1 VULCAN 6-BARREL ROTARY CANNON, 4 X AIM-9 SIDEWINDER & 4 X AIM-120 AMRAAMS OR 8 X AIM-120 AMRAAMS, CARRIED EXTERNALLY

Illustration: Battlefield Design

The F-15 has experienced no losses in aerial combat so far

"THE COCKPIT OF THE F-15 HOUSES A MULTIMISSION AVIONICS SYSTEM THAT IS SELDOM SEEN ELSEWHERE"

© Alamy

ARMAMENT

The F-15 is ready to perform in air-to-air combat and as part of a ground-attack fleet, with its equipment and armaments improved over the years. The A, C and D models are able to hold AIM-120 (AMRAAM), -9 (Sidewinder) and -7 (Sparrow) missiles on the pylons under the wings, while the F-15E comes equipped with precision guided munitions and a variety of payloads. There is also an internally mounted M-61A1 20mm six-barrel cannon with 940 rounds of ammunition in the right wing foot.

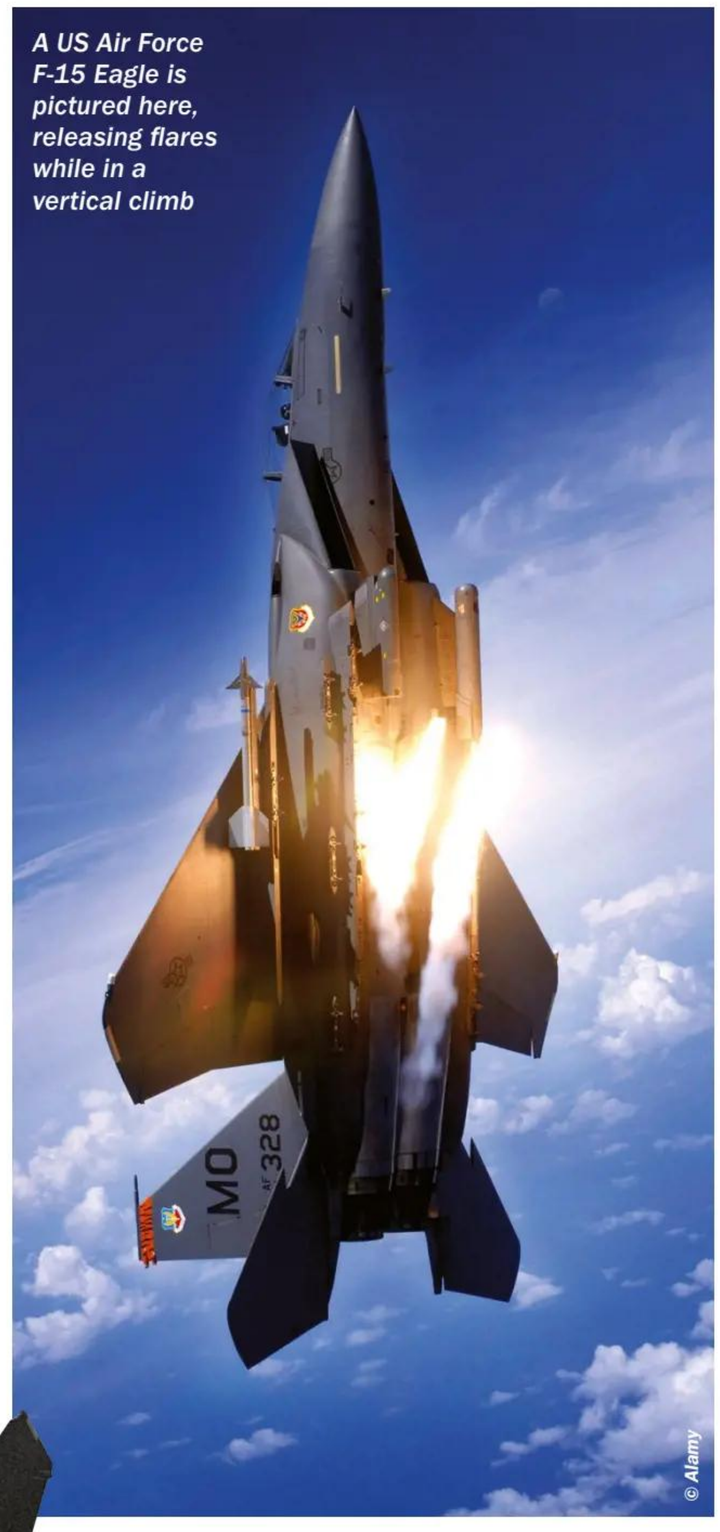
Some models of the F-15 Eagle are equipped with missiles under the wings

© Getty

COCKPIT

The cockpit of the F-15 houses a multimission avionics system that is seldom seen elsewhere. This includes a head-up display, advanced radar, an inertial navigation system and instrument landing system. The head-up display is projected onto the windscreen and displays all essential flight information gathered by the integrated avionics system.

Depending on the model, F-15s can seat either one or two people in the cockpit, but the pulse-Doppler radar system means that high- and low-flying targets can be tracked at any speed without being confused by any ground clutter.



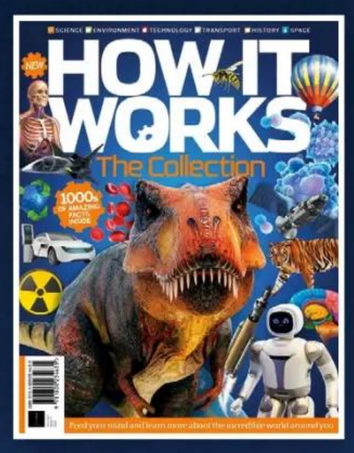
A US Air Force F-15 Eagle is pictured here, releasing flares while in a vertical climb

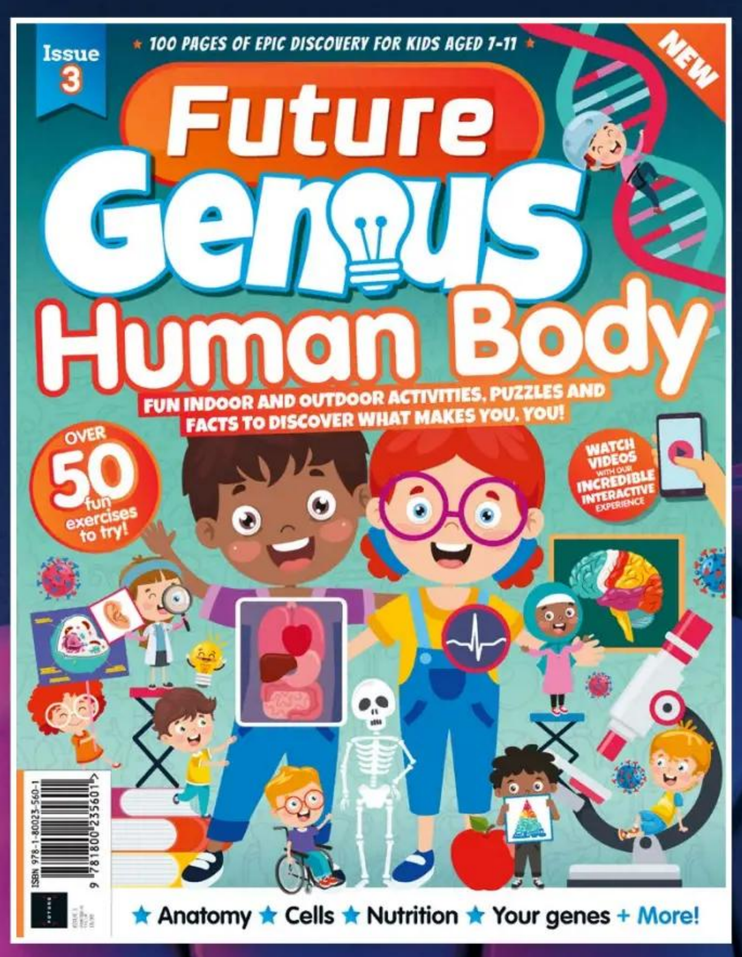
DESIGN

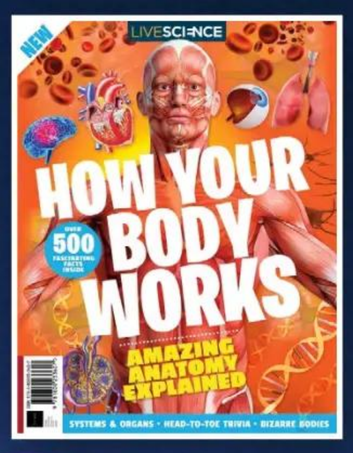
The fuselage of the F-15 is all metal and semi-monocoque, with a large-cantilever, shoulder-mounted wing. Twin vertical tails are mounted at the rear of the short fuselage, and large horizontal-ramp variable-geometry external-compression inlets are located on the sides of the fuselage ahead of the wing.

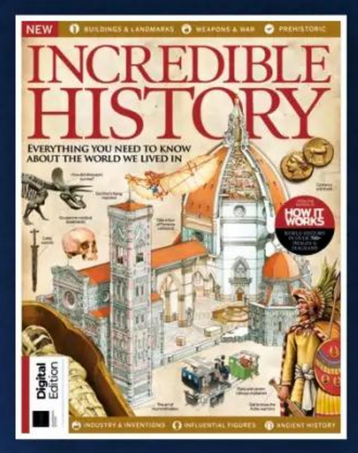
The main purpose of the F-15 was to dominate airspace as an air superiority fighter. This aim was certainly achieved thanks to its design, weaponry and technical specifications, with the plane still in use after five decades.

The F-15 is an all-weather tactical fighter that can achieve air supremacy









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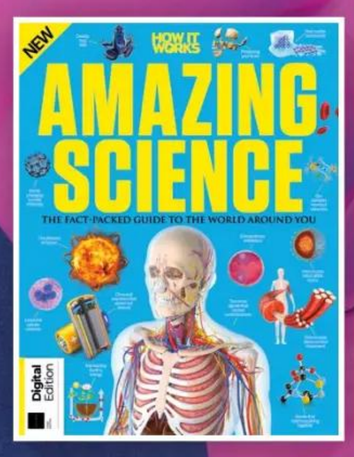

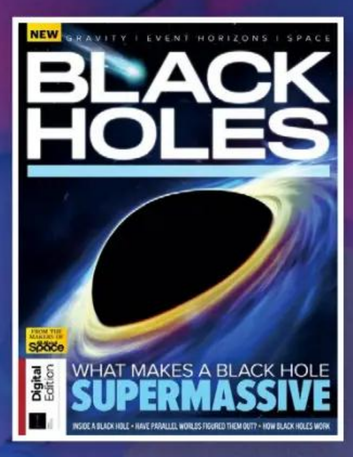

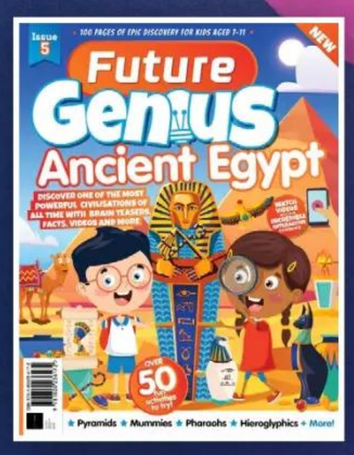

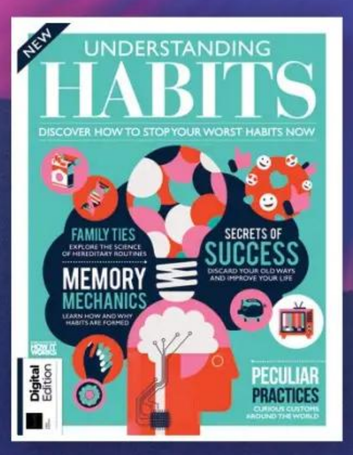

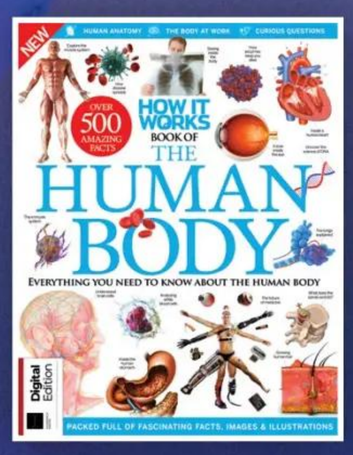

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